

THE OUTLINE OF NATURAL HISTORY



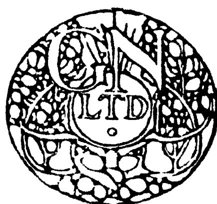
Photo: F. W. Bond]

SAM AND BARBARA, TWO POLAR BEARS, ON THE MAPPIN TERRACE AT THE LONDON ZOOLOGICAL GARDENS.

THE OUTLINE OF NATURAL HISTORY

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PREFACE

THERE are many effective approaches to the study of Natural History, but one of the most rewarding is to inquire into the everyday life of animals, and the diverse ways in which they have solved the perennial problems of hunger and love, foothold and persistence. For this inquiry into ways of living, the keynote of this book, brings us at once into sympathy with the animal, whose problems are anticipations of our own. Every living creature, up to its measure, is an actor in the drama of life, in which man plays his supreme part. All the world is a changeful stage on which the drama has been in progress for hundreds of millions of years, though it is only a very short day, in comparison to these, since man became an observer of the cast and an inquirer into the plot.

So our book deals chiefly with the life of animals as it is lived in Wild Nature, and for obvious reasons we have given a prominent place to mammals and birds among Backboned Animals, and to insects and spiders among Backboneless Animals. For these are the creatures whose ways are known in greatest detail and with most precision. It soon becomes plain that we cannot go far in our study of them without raising, though in a lightsome way, the fundamental questions of Biology or Life-Science ; and it is part of our aim here to show that there is a brain-stretching discipline in the old-fashioned Natural History, growing into the modern Ecology, just as much as in the more analytical studies of Anatomy and Physiology. But apart from brain-stretching, we also hope that there is in this book a sympathetic treatment which will induce many to share in one of the deepest, if not fathomless, joys of life.

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THE WAYS OF MAMMALS

THE Animal Kingdom may be divided into the Backboned or Vertebrates and the Backboneless or Invertebrates. In each of these two great divisions there are many Classes. Thus the great classes of Backboned Animals are: (1) the Mammals, which are mostly quadrupeds with hair; (2) the Birds, which are all bipeds with feathers; (3) the scaly Reptiles, such as lizards and snakes; (4) the naked-skinned Amphibians, like frogs and newts; and (5) the Fishes, with gills and fins. Among the Backboneless Animals are the Molluscs, like snails and bivalves; the Spiders and their relatives; the great class of Insects; the Crustaceans, like crabs and shrimps; the Worms of many kinds; the Starfishes, Sea-Urchins, and their kindred; the Jellyfishes, Sea-Anemones, and Zoophytes; the Sponges; and the Simplest Animals which consist of a single cell or unit of living matter.

We shall begin with the class of mammals, the class to which man belongs, though he is much higher than any of them. This class includes monkeys, carnivores, hoofed mammals, insect-eaters, gnawing mammals, and so on.

THE WAYS OF MONKEYS

The order of apes and monkeys (Primates) includes several different grades, but the highest monkeys have wits excelling those of all other living creatures save man. They

may be divided into (1) the New World Monkeys, like the Spider Monkeys and Howling Monkeys ; (2) the Old World Monkeys, like the Macaques and Baboons ; and (3) the Anthropoid Apes, which are also confined to the Old World, and include Gibbon, Siamang, Chimpanzee, Gorilla, and Orang.

It is always well to begin with the senses, for they are the gateways of knowledge and the triggers by which activities are set agoing. Monkeys are very well equipped as regards senses. While the eyes of a dog or a horse look out sideways, the monkey's eyes are directed forwards, as in ourselves. This is a matter of great importance, for it means that a large part of what is seen at any moment is seen by both eyes. This implies what is called *stereoscopic* vision, giving length, breadth and thickness to the picture. Monkeys can distinguish different shapes, even printed letters, and different colours. Bred to a forest life, where alertness is a life-or-death quality, they are quick to detect any sudden movement, or any new feature in their surroundings. The sense of hearing is acute, but the sense of smell is not nearly so keen as in a dog.

But one of the greatest differences between monkeys and ordinary mammals is *the free hand*. It is still used in walking about, but it is not indispensable for that purpose, as it is in a dog. It has become a climbing, grasping, lifting, handling organ, with an acute sense of touch and with a power of feeling around things. No doubt we see something approaching this in some other mammals, such as the squirrel, nut in hand, but monkeys stand by themselves in their power of manipulation and in the linking together of hand and eye. Monkeys use their hand like a tool, and every one knows how they enjoy taking a thing to pieces, or screwing the handle off a brush and screwing it on again.

RESTLESS EXPERIMENTING

To understand monkeys we must recognise that they are endowed with a fine brain. It is at a very high level, and we cannot look into the eyes of a vigorous monkey without



Photo:, F. W. Bond.

JOHN DANIEL II.

Unlike the popular conception of the gorilla, this creature is full of fun and tricks. Here he is seen playing football with a cap, with a basket for a goal.

seeing, as it were, that suggestions are crowding through its mind. The monkey is restless, and it is restless because it is so clever. Watch a cat or a dog, Professor Thorndike says; it does comparatively few things, and is content for long periods to do nothing. "Watch a monkey and you cannot enumerate the things he does. Everything appeals to him. He likes to be active for the sake of activity."

We see this in the fact that monkeys cannot be satisfied as long as there is anything to be found out. Rudyard Kipling tells us that the mongoose, Riki-Tiki-Tavi, made it his business in life to find out about things, but that is even more true of monkeys. It does not seem too much to say that they are curious about the world.

One of Professor Thorndike's monkeys happened to hit a projecting wire so that it vibrated. This interested him very much and he went on repeating the trick hundreds of times in the next few days. He got nothing out of it, of course, but it pleased him to make the wire hum.

Monkeys are often astonishingly quick in their movements, and when they get an idea into their head they follow it up with instantaneous action. The thing is often done before we detect what the monkey is going to do! In learning to link two things together, *e.g.*, a sound and an action, they are the quickest of all animals. Sally, a famous chimpanzee at the London Zoo, was taught to give her teacher the number of straws he asked for, and she soon learned up to five. When she heard the sound "five" or "four" or "three," she gathered the right number of straws, and earned her reward. Attempts to teach her above five were not very successful, perhaps because her patience was very limited. When dealing with numbers above five she very often doubled over a straw so that the two ends presented between her fingers and thumb looked like two straws. The doubling of the straw was probably an intelligent device for saving time, and she often resorted to it, though it was never rewarded by her teacher.

Professor Holmes kept an Indian Bonnet Monkey, called Lizzie, second cousin to the Macaque that lives on Gibraltar, and it was very interesting in what it could and could not do. The front of her cage was made of vertical bars which allowed Lizzie to stretch out with her arm. On one occasion an apple was placed out of reach on a board which had a handle that could be grasped. Lizzie immediately stretched out for the handle, pulled the board in, and got her apple. She had no hesitation, but perhaps it was one of the habits of her race to draw a fruit-laden branch within

reach. On another occasion Lizzie was given a corked vaseline bottle with a peanut rattling inside. She at once pulled the cork out with her teeth, obeying the instinct to bit at new objects, but she never learned to turn the bottle upside down and let the nut drop out. This is an interesting



Photo: F. W. Bond.

A GARDEN SEAT IN THE SUN.

Chimpanzees are sociable creatures and like to spend their leisure in company, rapidly degenerating when kept in solitary confinement.

example of the shortness of the mental tether. She used to get the nut eventually, and in the course of time she got it more quickly than at first, but she never *understood*. Her progress seemed to be due to dropping out useless movements, but this is a low-level kind of learning. If Lizzie had learned intelligently she would have turned the bottle upside down.

Monkeys are far cleverer than cats and dogs in learning how to open "puzzle-boxes," where the barriers have to be overcome in a definite order. This is connected with their greater manipulative skill. They try and try again, and drop out mistakes, thus rising above Lizzie's experiences, we can hardly say experiments, with the vaseline bottle. In one case a monkey opened a "puzzle-box" at once after an interval of eight months, thus showing a good memory. Some monkeys can be taught to find their way out of something like the Hampton Court Maze, a feat which probably means a memory of turnings and twistings, and it is interesting to read of two Macaques that they began to smack their lips audibly when they reached the last lap of their course, beginning to feel, dare one say, "We are right this time, the reward is near."

There is a common idea that monkeys are great mimics, and we suppose this is partly true. We once watched two chimpanzees washing out their cupboard and it was interesting to see them "wringing" the wet cloth in the approved washer-woman fashion. It is likely that they did this because they had seen it done. But the results of experiments with monkeys point on the whole to the conclusion that each monkey has to find out a solution for itself. Even with such a simple problem as drawing a piece of food within reach by using a crooked stick, it often seems of no use showing the monkey how it is done. But this is not invariably true, and this reminds us that there are many grades of monkeys, some much more intelligent than others.

What is certain is that monkeys are restless and yet persistent experimenters, that they often solve rather difficult problems in manipulation, and that they can remember solutions. Perhaps the cleverest monkey (or ape rather) as yet studied, was a performing chimpanzee called Peter, who could skate and cycle, thread needles and untie knots, smoke a cigarette and string beads, knock in nails and use a key to open locks.

One of Peter's best tricks was riding a bicycle in and out between five bottles set in a figure 8. Of considerable

interest is the fact that in using a hammer and a screwdriver he did not confuse nails and screws. On one occasion a peculiar kind of hammer was given him as a test; he carefully felt the two ends of the head and then used the flat one, not the round one. In the performance that Peter



Photo: F. W. Bond.

THE SQUIRREL MONKEY OF BRAZIL (*Chrysothrix*).

This is a gregarious and arboreal species of the tribe, but its long tail is not prehensile. The head is prolonged backwards. It feeds chiefly on insects, small birds, and eggs.

gave on the stage there were thirty-six separate acts which followed one another in orderly sequence, and when he was at his best there was no detectable prompting. The trainer seemed to do nothing but assist with the stage properties. Though the performance was evidently enjoyed by the ape, the strain was probably too severe, for Peter did not stand it long and died when he was about seven years old.



Photo: The New York Zoological Society.

SUZETTE.

A clever chimpanzee, that was not only a trick bicycle rider, but very much at home on roller skates. The opposable big toe is very well depicted in the illustration.

Of another trained chimpanzee called Suzette, Dr. W. T. Hornaday, Director of the New York Zoological Park, tells us in his delightful *Minds and Manners of Wild Animals* (1922), that she was a brilliant "trick" bicycle rider and was entirely at home on roller skates. "She could stand upright on a huge wooden ball, and by expert balancing

and foot-work roll it up a steep incline, down a flight of stairs, and land it safely upon the stage, without once losing her balance or her control." It is difficult to estimate the degree of intelligence which such a feat involves, but there can be no doubt that its success depends on rapid and sure practical judgments.

Every one must agree that apes and monkeys, like horses and dogs, cats and elephants, exhibit *intelligent* behaviour. We mean that they do things which cannot be satisfactorily described without supposing that the animals can put two and two together. We cannot make sense of what they do without supposing that they say to themselves inside their head, "If this, then that." We must credit them with doing a little thinking, with what is technically called "perceptual inference." That is to say, they have a little experiment game in their minds, the counters in the game being memory images or pictures of things. If they experimented with "general ideas," such as "man" or "reward," as we sometimes do, that would be reason or "conceptual inference," but there is no sure case of an animal rising above the level of intelligence.

It is very important to get this matter clear, so let us illustrate it in reference to the gorilla.

THE GORILLA

In 1918, Major Rupert Penny bought a young male gorilla in a store in London, rescuing him from "a daily atmosphere heated to 85 degrees and a nightly condition of solitude and terror." The child-ape was educated by Miss Alyse Cunningham, who kept a record of her pupil's progress. After his childish loneliness at night was removed, "John" began to be happy. He learned to like to be tidy; he fed chiefly on warmed milk and fresh fruit, also warmed; he ate slowly and behaved well at table. If he turned on the water tap he always turned it off again when he had finished drinking. He played by himself and with a child of three. He liked young animals, such as lambs and calves, but was afraid of the full-grown. He enjoyed playing to

the gallery, and would unlock the sash and throw the window up so that he might show off to the crowd below. He would clap his hands and beat his breast with his fists after a fashion which Du Chaillu described—only to have his story discredited. "John" was very cautious himself, and he was curiously nervous about people he was interested in; for instance, if any one looked out of a high window. He was not always "good," but no bodily punishments were of use. "We found out that the only way to deal with him was to tell him he was very naughty, and push him away from us; when he would roll on the floor and cry, and be very repentant, holding one's ankles, and putting his head on one's feet."

In this connection it is interesting to notice his behaviour when his playmate, a little girl of three, had a tumble. "If she ever cried, and her mother would not go and pick her up, John would always try and nip the mother, or give her a smack with the full weight of his hand, evidently thinking she was the cause of the child's tears." But it is very difficult to be sure what the child-ape was thinking. Perhaps it was something like this: "My little playmate is crying, crying as I do on the floor when I have been pushed away by those I love. What shall I do to her mother, who will not even lift her up again? I shall go and strike her mother even if I have to cry, too." If the ape thonght anything like this, then what he did was *intelligent* behaviour—mistaken, of course, just as our own often is, but nevertheless intelligent. If, on the other hand, we could believe that "John Gorilla" said to himself: "This is gross injustice, making my charming playmate cry; I, John Gorilla, must protest," then we should have to credit him with Reason or using general ideas. ' But this interpretation is far too generous—and the first likewise. The probability is that the child-ape was angry and puzzled, and that he struck the mother, as a child sometimes does, with no more intelligence than when he struck his own breast with his fists.

Miss Cunningham's tell us of a "very human" incident "A piece of fillet beefsteak had just come from the butcher

Inasmuch as occasionally I gave him a small mouthful of raw beef, a small piece of the coarser part of the steak was cut off, and I gave it to him. He tasted it, then gravely handed it back to me. Then he took my hand and put it on the finer part of the meat. From that I cut off a tiny piece, gave it to him, and he ate it. When my nephew came home he wouldn't believe it, so I tried it again, with the same result, except that then he did not even attempt to eat the coarser meat." The first episode, with its impromptu action, was of course more interesting than the second.

One day when Miss Cunningham was waiting to go out, "John" begged to be allowed to sit on her lap, which was his seat of honour. But Miss Cunningham refused "John's" request as she happened to be wearing a light dress which might have been made dusty. After his wont, "John" lay down on the floor and sobbed. He soon got up, however, and fetched a newspaper, which he spread out on his teacher's lap! This, according to Miss Cunningham, was the cleverest thing he ever did; and, if one were generous, one might suppose that he argued to himself: "I have been refused my seat lest the dress be marked, but a newspaper will prevent this, so I shall fetch a newspaper." If this was what happened in "John's" mind, and if he had never seen a newspaper used in this way, his behaviour would deserve to be called very intelligent, if not rational. But in judging it scientifically, one has to inquire whether the gorilla had ever seen Miss Cunningham using a newspaper to cover the bottom of a drawer or a shelf in the wardrobe; one has also to ask whether Miss Cunningham was accustomed to put on an apron when she used a brush to tidy "John"; in short, one needs to know more than the story tells. In any case, the gorilla's behaviour was intelligent, but what degree of intelligence it illustrated requires further inquiry. Our point is that Natural History has become more critical; it is not content to accept every record on its face value.

There are two or three different kinds of gorilla—the West African lowland species (*Gorilla gorilla* and *Gorilla matschiei*) of the North Congo Forest, the Cameroons, and

the Gaboon, and the highland Eastern Congo species (*Gorilla beringei*) from north-west Tanganyika and the volcanoes of Kivu. The last species has been recently studied by Mr. Barns, who has had unique opportunities of observing the greatest of the apes at home.

The Highland gorilla ascends the mountains to a height of 10,000 feet, and that is associated with the fact that the bamboo, which forms its staple food, grows at high elevations in these parts of Tropical Africa. With the mountainous haunts we may also associate the thick coat of dark hair which covers the body except the bare chest; and on the crown of the head there is a magnificent shock that suggests a busby.

The gorilla's proportions are on a big scale. One that Mr. Barns shot was six feet two inches from the sole of the foot to the crest of thickened skin on the top of the head. In another individual the span of the arms was ninety inches, and the weight over thirty-two stone. Even with ju-jitsu an athlete has no chance with a full-grown gorilla. It can break a thick branch in its great hands, or a lion's forearm, or a leopard's neck. It "could doubtless tear even a Hackensmidt or a Sandow limb from limb in a few minutes." If a man has been unfortunate enough to enrage a gorilla he must either shoot or start a gramophone. Not that the music soothes the savage breast: it is for some occult reason unendurable.

We were brought up to believe that apes remained apes because they persisted in remaining up trees, whereas the ancestors of man came down to terra firma; but Mr. Barns is emphatic in calling the gorilla non-arboreal. Neither its hands nor its feet are suited for climbing trees, but the huge creature has a curious way of walking quickly over a bamboo forest, using the stems like stationary stilts. An onlooker from a high vantage point may see the black heads bobbing up and down and the huge arms rising and sinking as if the monsters were swimming in a green sea! On the ground the gorilla seldom walks erect, except when it is holding on to branches overhead, or when it is attacked by man, who is probably its only serious enemy. In point

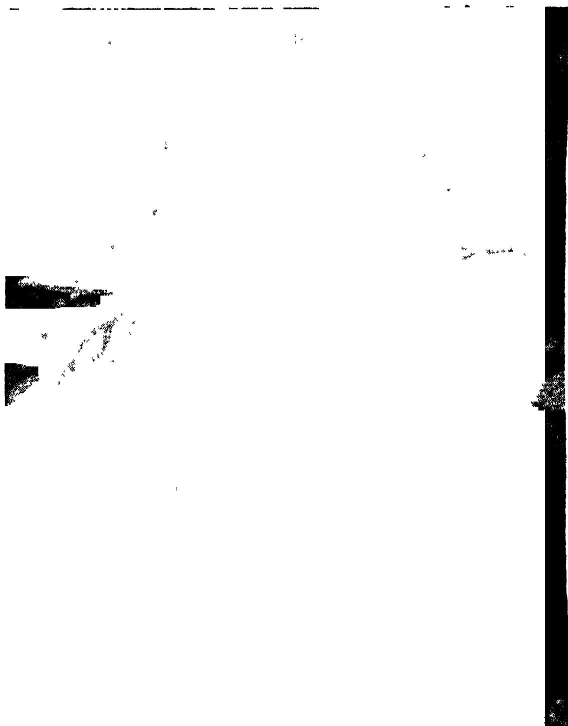


Photo: T. Alexander Barns.

HEAD OF GORILLA.

The Mountain Gorilla (*Gorilla beringei*) from the highlands of Tanganyika. It is marked by a hard thickening of the skin on the top of its head, a great shock of hair, and some other peculiarities. It feeds mainly on the tender parts of bamboos, and does not seem disposed to live dangerously. Its great strength keeps off almost all enemies save man.

of fact the gorilla shuffles along on all fours, with the fingers doubled under so that their backs are in contact with the ground.

The Highland gorilla never makes a "nest" in trees, but sleeps on or near the ground. There is practically no danger, and the only thing to be avoided is being drenched by one of the frequent rainstorms. Thus the gorilla may

sleep in a hollow tree or under dense overhanging branches, or in a hole lined with ferns and twigs, or on a platform of half-broken bamboos. On such a bamboo platform the gorilla often enjoys a sun-bath, reaching around now and again to pluck a tender leaf.

The Highland species seems to be less omnivorous than the western forms, for it is not keen on fruits and it does not dig for roots. Honey it may take, when it can, but mainly it feeds on the tender parts of bamboos and on juicy herbage, such as docks, sorrels, and hemlock.

According to Mr. Barns, gorillas go about in small family parties, consisting of the father, several fully grown females, and four or five children. But we should like more numerous and critical observations on this important question. "Old man" gorillas, who have lost their family status, are sometimes found living alone, "having been beaten and thrown out by a younger and stronger rival." They are not to be regarded as crusty old bachelors; they are superannuated fathers.

Can we obtain a closer view of the gorilla? It has a magnificent chest development (sixty inches), a massive jaw, and most formidable teeth, a roar like a buffalo's but with considerable scream. Usually, however, gorillas are quite silent, which shows that they are not naturally quarrelsome. When they are interested and curious they utter a loud whine like a great dog, and follow this by beating on the bare breast with their fist. This produces a resonant "clopp, clopp, clopp," which may be a danger-signal or a kin-signal. "Also, I think to 'hearten' themselves, for I have heard it when there was no possibility of the animals being alarmed."

A full-grown male gorilla, over six feet in height, a study in black and grey, sometimes with a hint of red-hairedness, must be a very impressive sight, but Mr. Barns assures us that a London crossing is more dangerous.

The gorilla would be accorded a higher rank of handsomeness if his arms were not too long for his legs, for this offends the human sense of proportion. The young ones look too like "pot-bellied teddy-bears" to be awarded

more than a leaf or two off the palm of beauty. But no gorilla would be condemned as ugly by an unprejudiced jury.

Gorillas are not quick of sight, hearing, or smell; they trust to their herculean strength; they are as clever as they need to be, and experiments show that they have great potentialities of intelligence which can be awakened by appropriate liberating stimuli. It is an erroneous idea that an animal's inheritance, or a man's, may not include unused intellectual reserves. "Free from molestation, famine, or disease," gorillas probably live to a much greater age than man.

The gorilla's reputation for ferocity is probably for the most part a misunderstanding. According to Mr. Barns the wild gorilla is "a great bluffer, certainly not looking for trouble." On a recent Scandanavian expedition no fewer than fourteen gorillas were shot, far more, one would think, than were necessary for scientific purposes; but Mr. Barns strikes a humaner note: "When hunting these great apes no one with a spark of feeling can free himself from the thought that killing them is akin to murder. They are so very human and interesting, the young ones so unsuspicious of danger, the older ones so full of curiosity, that hunting them can hardly be called sport." One is glad to hear even talk of a Congo sanctuary for gorillas, for although we cannot number them among our ancestors, they are included under our trusteeship, and there are no creatures more deserving of all the humane protection that man can offer. Long live the gorilla!

Professor Köhler, a psychologist, who has had unusual opportunities of studying chimpanzees, tells us how even a feeble one will try with all its strength, as well as with beseeching gestures, to save another from being punished by the keeper; and how a female rushed to the help of an invalid youngster that had collapsed on the ground. Though not its mother, she was most motherly, and laboured strenuously to lift the prostrate youngster to an erect posture. There are scores of similar examples of good feeling and effective action.

On one occasion, Professor Köhler buried a pear in the sand before the cage of a chimpanzee who eyed him watchfully. After an interval—varying in different experiments and rising to an hour—a stick was put into the cage. The ape seized it promptly, thrust it between the bars, and dug up the pear. This must be ranked as intelligent behaviour.

In other experiments with several chimpanzees an interval of sixteen hours was allowed to elapse after the burying of the pear. But when the opportunity was given, the apes went straight to the cache in the sand and dug up the fruit. The necessary control experiments were made, and there seems no doubt that this was a case of intelligent behaviour. There was a memory-image of a desirable object and there was a precise controlling of movements in relation to a recollection of the position of the hidden treasure. But no one who uses the word " reason " to mean something beyond " intelligence," would say that there was in the fruit-finding any hint of reason.

The chimpanzee is an animal of the trees, though it spends a good deal of time on the ground. It lives and sleeps among branches, but comes down to grub for roots and tubers, or if it thinks fit to leave one tree for another. At night the chimpanzee makes a platform of fresh, leafy branches some fifteen or twenty feet up, and sleeps there till daybreak, when it adds its shouts to the monkey-chorus. Although it often indulges in hooting, it can be very quiet in the trees, feeding silently and dropping nothing on the ground to give a sign of its presence. It does not seem to have a large vocabulary. Dr. Cuthbert Christy writes: " During the day the chimpanzee spends most of his time in some big tree, taking life seriously, picking young shoots or fruit, fondling friends and grimacing, or doing aimless trapeze work. Occasionally he dozes on some fallen log. At the first sign of danger the wary old male forsakes his family, and coming down from the tree-top with a few acrobatic swings and a drop, makes off along the ground. He uses his great arms to help himself along, to push off from trees in his haste, or for swinging creepers and branches out of the way, rather than for running with." That the

chimpanzee does not need its arms for walking is clearly shown by its tracks, for often only footprints appear, with here and there a knuckle mark, as the animal wanders through the forest, picking leaves as it goes.

There are a few cases, however, where the behaviour seems to us to rise close to the rational level. Dr. Hornaday tells of a captive orang named Dohong, who seemed to have the joy of discovering or inventing the lever. "As fairly and squarely as Archimedes discovered the principle of the screw," Dr. Hornaday says; but the use of the word "principle" is begging the question. What happened, however, was very remarkable. Dohong found out for himself how to use a lever, and then he proceeded to make other levers, sometimes of larger size. This was very intelligent, for it was getting beyond a particular situation. A lesson learned on one occasion was utilised on other occasions when the particulars were different. With the utmost good nature and cheerfulness, Dohong made use of his levers to wrench off the brackets in his cage and to destroy two large sleeping boxes on the balcony. For a long time he had been vexed because he could not put his head out between the bars of his cage and look round into his next-door neighbour's house—a very natural desire. "Very soon after he discovered the use of the lever, he swung his trapeze bar out to the upper corner of his cage, thrust the end of it out between the first bar and the steel column of the partition, and deftly bent two of the iron bars outward so that he could easily thrust his head outside and have his coveted look." If ever a creature delighted in "bringing things off," it was this orang.

To sum up, we must credit apes and monkeys with a restless, alert brain, with experimental eagerness, with long memories in some cases, with a capacity for apprehending relations so that they could argue from what they had done in one case to what they should do in a somewhat similar case. In short, some of them attain to a high degree of intelligence.

II

THE WAYS OF BRITISH MAMMALS

MAMMALS are mostly quadrupeds with a covering of hair; and they all give milk to their young. Those in Britain belong to the following orders: Carnivores, Insectivores, Bats, Rodents or Gnawers, Ungulates or Hoofed Mammals, and Cetaceans or Whale-like Mammals. We must select a number of representative types, for, though the list is not a long one, we cannot discuss them all.

BATS

Towards a dozen kinds of bats may be regarded as genuinely British, notably the Greater Horseshoe, the Lesser Horseshoe, the Pipistrelle—smallest of all, the Barbastrelle, the Noctule—largest of all, the Serotine, the Whiskered Bat, Natterer's Bat, Daubenton's Bat, and the Long-Eared Bat. They are the only mammals that have the power of true flight, and they are, in many other ways, bundles of peculiarities.

The wing is formed by a double fold of skin, which usually begins at the shoulder, extends along the upper margin of the arm to the base of the projecting thumb, thence between the long palm-bones and fingers, and down the sides of the body to the hind-legs, and even to the tail, if there is one. There are strong breast muscles for flight, and they are fixed to a slight keel on the breastbone; the thumb is always clawed, but the other digits are unclawed, except the second one in most of the fruit-eating bats. All our British bats are insect-eaters, and the back teeth have sharp crunching prominences or cusps. The hind-limbs are relatively weak, and are used when the creatures hang themselves up to sleep; the knee is turned backwards like an elbow; the

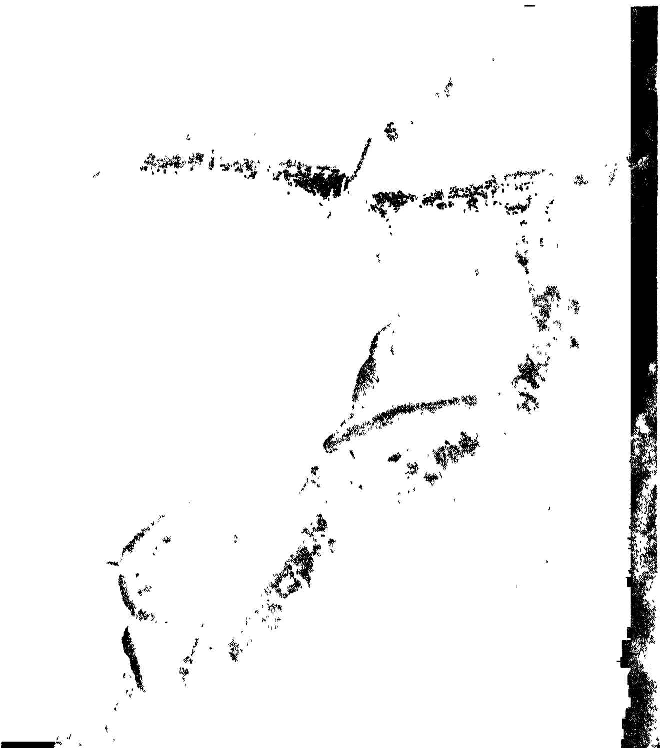
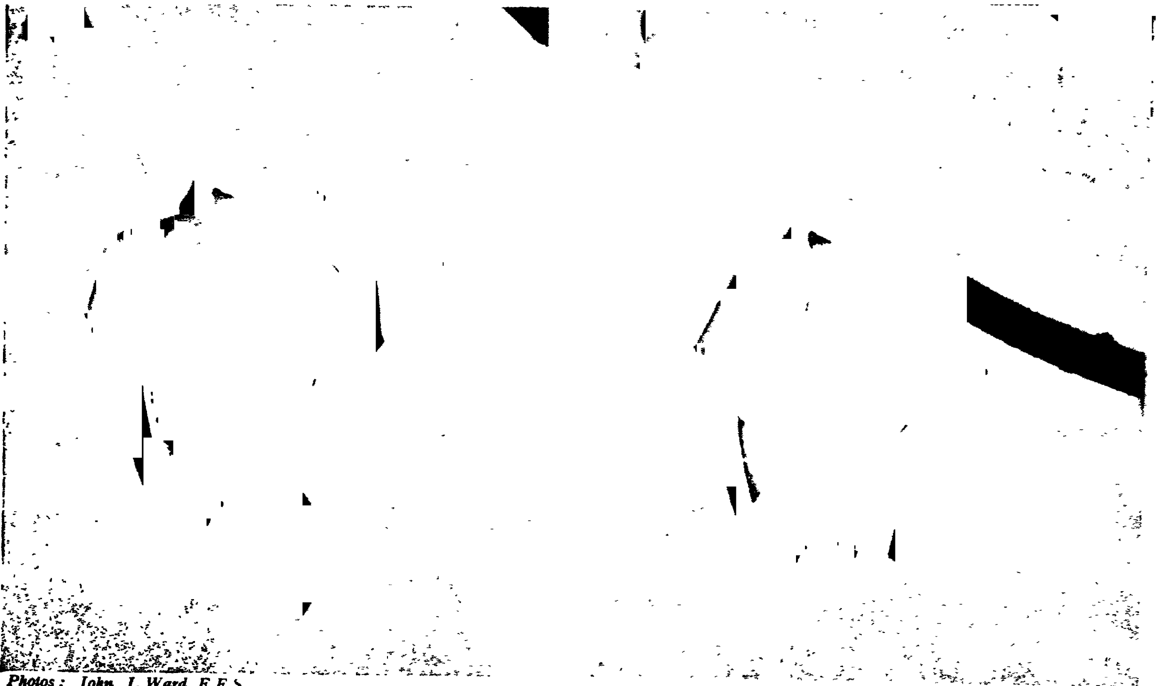


Photo : Frances Pitt.

THREE NOCTULES, OR GREAT BATS (*Nyctalus noctula*).

The noctule is widely distributed in Britain, a gregarious frequenter of trees, of a yellowish colour, with long, soft fur. It feeds mainly on cockchafers and other large beetles, hunting them in mid-air. The spread of wing, from tip to tip, may be fifteen inches.

five toes are clawed. There is usually a skin basket (or inter-femoral membrane) between the hind-legs, with the tail in the middle. The skin is exquisitely sensitive, so that bats do not knock against things in the dark. The temperature of the body is high. There is usually a single young one at a time, and the mother carries it about on her aerial journeys.



Photos: John J. Ward, F.E.S.

The bat, alighting on a branch, grips firmly with its toes;

it tucks its huge ears away, one at a time,





Photos: John J. Ward, F.E.S.

hiding them under its neatly folded leather wings, which it wraps round its body, leaving only the inner flap of the ear projecting.

THE RED DEER

Our handsomest British mammal is certainly the Red Deer. It stands forty-two to fifty-two inches high at the shoulders; it may be over six feet long; it may weigh thirty stone—yet it can run fifty miles at a stretch, and the word "steep" is not in its dictionary. It is a very graceful animal, holding its head high, and very light on its feet. It can clear a seven-feet fence and twenty feet of a chasm, and there are a good many places called "Hartsleap" throughout the country. The deer is also a good swimmer and a brave fighter. The coat is reddish-brown, short and glossy, in summer; greyish brown, long and rough, in winter; and, after the manner of deer, the young are spotted till the spring after their birth. The dappling is perhaps suited for concealment in the broken light of the copse. When a young animal shows a feature that afterwards disappears, it is in many cases to be regarded as an old-fashioned feature that the ancestors of the animal exhibited. Perhaps the Red Deer's ancestors had spots.

For a great part of the year the stags and the hinds live apart. The stags frequent the higher levels, and we sometimes see them on a ridge, silhouetted against the sky. The annual growth of antlers comes to an end about the beginning of August, and the hot skin or velvet, which was for a time rich in blood-vessels, is rubbed off against branches or in the peat-bog. About the end of September is "the day of the roaring," when the stag sends forth his challenge and invitation. There are savage combats between rivals, and the conqueror wins several wives. The calving is in May or June, and the young one (there are rarely twins) is hidden among the bracken and heather, or at the side of a wood.

Antlers, confined to the males except in the reindeer, are solid outgrowths of the forehead or frontal bone. They fall off and are replaced each year, like the leaves of a tree. In the first year, when the calf is eight to ten months old and still with the hinds, a mere knob grows out. This is a permanent structure. In the second year there is, in addition, an unbranched stem. Next year the new antler

bears a brow-point or tine, growing forward and upward from near the base of the main stem or beam. Next year a bay-point is added, and these first two "defend the brow of the stag." Next year, some way up the new beam, there is added a tray-tine, obviously French for third. So on it goes, beginning afresh each year and adding point after point until the climax is reached, after which the annual regrowth gradually wanes. A "full antler" shows brow, bay, tray, and three points on the top, six altogether, but there may be a dozen or even a score of points on a really splendid head.

The hot, almost inflamed, skin or velvet is very sensitive, and this saves the stag from knocking his antlers against branches, which would lead to abnormal growth. Very remarkable is the automatic arrangement, set agoing as soon as growth begins, which cuts off the supply of blood to the velvet and the antler-bone, and secures the shedding in March. It is usual to regard the antlers as weapons, but it must be remembered that hornless stags or "hummels" fight very effectively with teeth and hoofs; perhaps antlers are merely exuberant outcrops of masculine vigour. Foxes and eagles occasionally kill the calves, but the adult Red Deer has practically no enemies, and if the antlers were weapons against enemies it would be difficult to explain their absence from the hinds. Moreover, the forefeet and the teeth are much used in the stags' fighting. The cast antlers are not often seen, partly because the stag, who is rather sorry for himself at the time, gets rid of them in solitary places where there is dense growth of vegetation; and partly because he gnaws at them after they are cast. The marks of the teeth are sometimes quite plain.

We associate the Red Deer with mountains and moorland, and quite rightly. But it was originally, strictly speaking, a forest animal, and its survival in more or less bare places like Exmoor and the Scottish Highlands testifies to its vigorous constitution. It is fond of the leaves of trees, such as lime, beech, birch, alder, and hazel; but often, of course, it has to be content with grass and heather-tops. As distance means little to it, we are not surprised that it

should roam about at dusk and dawn, seeking pleasant things in field and orchard, even going down to the distant shore to lick the salt off the rocks. Red Deer show a great liking for acorns and apples, cabbages and carrots, potatoes and turnips, young corn and ripe corn, and, unless kept within bounds by means of high fences, they often do much damage. In his well-known *Red Deer*, Richard Jefferies noted that whereas the hinds eat turnips down as sheep would, the stags are extraordinarily wasteful. "The stag as he walks across the turnip field bites a turnip, draws it from the ground, and throws it over his shoulders, the jerk detaching the fragment he holds between his teeth, which is the only portion he touches. He takes but one bite at each turnip, casting the remainder aside in this way, and his course can be traced from one side of the field to the other by the turnips pulled and thrown away after his snatch. In this disdainful manner he damages far more than he actually eats." The Red Deer's hard times come when the land is covered with snow.

The Red Deer is the only wild survivor of the larger mammalian fauna which used to find a home in Britain, and we cannot but regard him as an admirable aristocrat. To strength he adds subtlety—destroying the scent by crossing and recrossing the stream, or seeking a rock where he may stand at bay without risk of being surprised from behind. The hinds utter an alarm call, "Bruach," bidding the calves lie quiet; they will even force the restless youngsters down among the bracken. The stags post sentinels; they can scent a man a mile off; their hearing and eyesight are extraordinarily acute.

Compared with the remains found in peat-bogs, the Red Deer of to-day seem to be dwindling in stature and in thickness of bones and antlers, and this may be connected with the persistent reduction of the forests. It is to be hoped that the dwindling will not go too far, and that the Red Deer will continue in vigour on those moorlands which can hardly be put to better use than preserving such noble animals. For, as Jefferies says, "there is no more beautiful creature than a stag in his pride of antler, his coat of ruddy

gold, his grace of form and motion. He seems the natural owner of the ferny coombes, the oak woods, the broad slopes of heather." Long life to the Red Deer !

THE FOX

Reynard the Fox is one of the few large-sized survivors of the old Forest Fauna in Britain. Another good reason for giving it prominence is that since the last wolf was killed in Britain (about 1743), the fox has been the only native representative of the dog tribe of the Carnivores. A very fine representative it is, with its handsome variable coat, usually reddish-brown above and white below ; with its tapering muzzle which suggests inquisitiveness ; with its large black-backed triangular ears that indicate alertness ; and with its bushy tail which may be half the length of the almost yard-long body. We may have strong convictions as to the relations between the fox and poultry, but there is no denying that the fox is one of the handsomest of wild animals. The dog-fox is rather larger and handsomer than his mate.

The fox (*Canis vulpes*) is a solitary, for the sexes live separately, except at the pairing time, and the hunting is always on the " each for himself " plan. Sometimes a natural hole or a badger's burrow is used as a retreat ; usually the fox digs an " earth " for itself. Most of the hunting goes on in the gloaming, or under cover of darkness, or in the early morning ; and thus the fox is not such a familiar animal as one would expect from its numbers. It often lurks unsuspected in tangled woods that people pass every day. Long distances may be covered in a night and great daring and ingenuity may be shown in getting at coveted booty. It is said that a speed of twenty miles an hour may be reached when the fox is hotly pursued, and there are many stories of foxes baffling the hounds by finding some unexpected refuge—even below the surface of a stream. There is no doubt as to the alertness of its senses and the nimbleness of its wits. It is not for nothing that the fox is second cousin to the dog.

The length of the fox's bill of fare is also noteworthy, for it is always easier for a creature to survive when it can make many different kinds of meals. A fox will eat rabbits and rats, chickens and ducks, pheasants and partridges, lambs and leverets, field voles and water voles, grouse from the moor, frogs from the marsh, and crabs from the seashore. Cases are known of foxes condescending to eat insects, but this is little more than a curiosity, like a man eating locusts. The fox's teeth are very like those of a dog, and the same in number. Very conspicuous are the sharp canines that give the killing grip, and one of the back teeth on each jaw above and below has a particularly sharp cutting blade, well-suited for snapping slender pieces of skeleton, or severing tendons, or getting the last shreds of flesh off a big bone.

Like many other Carnivores, the fox has a scent-gland beneath its tail, from which there comes a slightly greasy secretion with an odour disagreeable not only to man, but to some wild mammals as well. It probably helps the fox to recognise the vicinity or the track of its kindred, but there is evidence that the animal may occasionally behave like the skunk and use the repulsive substance to induce its enemies to pass by on the other side.

Another remarkable habit is that of "feigning death," when the fox lies unmoving and awry after it has been struck, but uses its first opportunity to make a sudden bolt for freedom. In lower animals this assumption of immobility usually means a sort of fit or catalepsy; in the fox, however, it may be in part a deliberate ruse. Its bolt is sometimes preceded by a shrewd snap at its captor.

Foxes breed in winter, and the males sometimes fight savagely for a desired mate. A quaint detail is the sudden flicking of the brush in a rival's eyes. The mother carries her young for about two months before birth, and the cubs —three to as many as seven of them—are born at the end of March or the beginning of April. From the time of birth to soon after the opening of the eyes they have a uniform sooty colour; this changes into tawny above and smoke-grey below; much later they begin to look like

their parents. The cubs are suckled for a month, and then they are fed for a while on rats and voles and other tender things. The vixen is indefatigable and intrepid in finding food for her family. She has been seen hurrying home with half a dozen field voles in her mouth. Like many other carnivore mothers, she teaches her offspring, who remain with her till September, playful and delightful creatures. Both the schooling and the playing greatly increase their chances of success in their subsequent struggle for existence, but eventually the vixen cuts the apron-strings, and the young ones are driven off to fend for themselves. They go off on separate paths, Ishmaelites from the start, and seek for unoccupied territory. They are not full-grown till eighteen months old. The playfulness we have just mentioned is sometimes turned to direct use. For a fox, like a stoat, will sometimes gambol in an extraordinary manner (chasing its own tail, for instance) in the presence of rabbits, who stand by, interested and amazed spectators, until the clown suddenly makes a snap at a throat and the comedy ends in a tragedy!

There is no evading the charge that foxes kill lambs, especially on hill-farms. The remains have been found at the den, and the circumstantial evidence is convincing. Moreover, like some other Carnivores, the fox sometimes "runs amok" and kills more lambs than he can possibly use. We take this to mean that when the killing instinct gets agoing, *and the stimulus persists*, there is no stopping the urge. And we should remember what an extraordinary experience it must be for a wild Carnivore to come on a field with a hundred young lambs! There is nothing like that to be seen in the whole of Wild Nature—not even among wild sheep.

The fox has been called "the nightly robber of the fold," but perhaps the "fold" oftenest visited is the poultry-yard. From a detached Natural History point of view the depredations of Reynard the Fox on chickens, ducklings, goslings, and the like are often of great interest, they show such cleverness. But the poultry-keeper cannot be expected to take this point of view! The loss is often

serious, and though one suspects that the vanishing fox is sometimes a convenient scapegoat, there is no getting past the remains of victims found at the den.

Another charge is that the fox levies a heavy toll on birds that nest on the ground, such as pheasants, partridges, and grouse. This also must be admitted, and it is readily intelligible that in places where "game" birds are important, *e.g.*, on high moorland, the number of foxes must be strictly controlled. There are curious circles in these inter-relations of living creatures : the more foxes the fewer pheasants, one may say ; but it is just as true that the more pheasants (or pheasant-preservers) the fewer foxes there will be.

The final charge involves greater difficulty. It is that in fox-hunting counties foxes are preserved to an extent that is prejudicial to agricultural interests, and that the hunt itself does considerable damage to cultivated land. In most cases, however, compensation is made to farmers for damage that can be traced to either of these causes. The question of fox-hunting in itself is outside science, but the probability is that if fox-hunting stopped there would soon be no foxes. Just as turkeys have persisted because man has thrown over them the shield of domestication—for the Wild Turkey seemed, till recently, a doomed bird —so foxes survive in a highly cultivated country because they are hunted !

The list of British mammals is a short one, and it would be a loss to the general interest of the country if the fox disappeared. It cannot, indeed, be ranked, like its second cousin the wolf, as a fierce animal dangerous to the lieges, but there is no doubt that it does a considerable amount of harm—little, however, compared with that done by rats. The question arises whether there is much to be said for the fox except that it is an interesting and handsome animal, and that it affords good sport. The answer is that the fox helps to preserve a wholesome Balance of Nature—for it keeps a check on the multiplication of rabbits, rats, mice, and voles. We have already referred to the number of field voles that the untiring vixen catches for her cubs. That

alone should cover a multitude of depredations. At the same time we must conclude that the multiplication of foxes must be kept under control.

It is possible that the difference between the smaller "terrier foxes" of the lowlands and the larger "greyhound foxes" of mountainous regions is due to the sterner struggle for existence in the uplands and northern parts. The survivors will tend to be finer specimens than those seen in areas where foxes are "preserved" and hunted! But it may be that there are also racial differences; and it must be remembered that large numbers of foxes have been introduced into England from the Continent.

We cannot leave the fox without recalling that it has been a native of Britain since Upper Pliocene times, and that it has survived in spite of heavy odds, the most serious of all being the destruction of the great forests where it originally found shelter. It has survived because of its swiftness, its alertness, its burrowing and nocturnal habits, the maternal care, and the education of the young. But part of its success is the reward of sheer cleverness. The fox kills its own scent, plays 'possum and escapes at the last moment, makes a trap go off without being caught, and drifts down a river like an old potato-sack until it is safe to land. We cannot wonder that Bacon advised statesmen to study the fox! As an aid in this study we would strongly recommend John Masefield's "Reynard the Fox"—for that reaches an understanding which science can only approach.

THE HARE

One of the sure signs that the Spring has really come is the behaviour of the March hare as it rushes across the field. It is almost beside itself with the desire to mate—the pairing urge. Its mood at this season is high-strung and hot-blooded, quite different from its usual temper throughout the year.

The Common Hare might be called a gentle Ishmaelite. Every one's hand is against it, but it is against no one unless it be greatly roused. Fox and otter, stoat and lurcher, and

various birds of prey are but a few of its many enemies, and the list used to be longer when polecats and wild cats were common in Britain. We cannot say, however, that it lives in the bondage of fear, for it is singularly fitted to elude its enemies, and it knows it, too. It seeks resting-places from which it gets a good look-out over the surrounding country; it has long-sighted eyes, quick ears, and keen smell; it utters a danger call by grinding its front teeth; its heart is such that it can put on full speed the moment that danger is signalled, it rejoices in an uphill race; it criss-crosses its tracks so that even the fox is baffled; it disappears like an arrow when it is startled, and even when it is resting among the ferns and herbage, or on a ploughed field, it is almost invisible save as to its wide, staring eyes. Much as it dislikes wetting its coat, which is slow to dry, it will swim a broad river to baulk pursuit or to reach greatly appreciated dainties, like musk and camomile. Epicure as it is, fond of the tender corn and the sweet trefoil, of wild thyme and the seashore pea, it has a long bill of fare, reaching from lichens on the rocks to the twigs of furze-bushes, from dandelions to bramble-berries. And it always makes for success when an animal can find sustenance in a great many different kinds of food.

It has been said that the Common Hare has the maximum of enemies, and yet it is so well endowed with capacities of sense and muscle and with instinctive ruses that it can outwit them all. Let us take three more illustrations of fitness. How simple and effective is its habit of taking a great leap from or into its "form" or nest, so that the scent-track is interrupted. A hare has been known to make a clean jump of three or four yards from its resting-place, and it often breaks its scent in the field. How interesting is Mr. Tregarthen's note in his fine *Story of the Hare*, that the doe leaves little scent whilst her young ones are helpless, that is about the month of April. How striking is the fact that she will sometimes divide her litter, when it reaches to five or six, so that there are two or three nests, each with one or two leverets—a quaint case of not putting all the eggs into one basket. When a particular nest becomes dangerous,

when a hungry vixen, for instance, gets wind of it, the doe hare will transport the leverets to a safer place, carrying one at a time in her mouth as a cat does her kitten. This, of course, is done at dead of night, and it is indeed at dusk and dawn that hares are generally most active. They positively dislike the glare of day.

Elusive is the word for a hare, but at the breeding season in March the instinct of self-preservation wanes before sex-passion. The cautious hare becomes reckless of danger, showing itself in the open at all hours of the day. The bucks race about at a high speed searching for the coy does and chasing them in circles when they find them. Rivals fight savagely, kicking with their hind-legs and boxing with their paws—a common trick is for one to jump over the other, kicking back as he clears, and this is sometimes fatal to the under hare. When exhausted with racing and fighting, the rival bucks sit and stare at one another by the half-hour. Then one will suddenly get up and dash over the lea, not with the usual easy loping canter, but at a tearing gallop. We smile to one another, and say, " March hare."

Of course there is plenty of racing and playing and fighting in other months, but it is mostly done on the quiet, whereas in March (and sometimes in August) the madness of love is recklessly obtrusive. A wearied hare with bedraggled fur is a melancholy sight, but, in spite of what most of the poets say, the spirit of the creature is quite otherwise, being gay and buoyant. The leverets sometimes play merrily in the light of the moon, and there is no melancholy in the way a hare jumps on an impertinent weasel. We should notice, by the way, that the buck hare is rather a roving lover, very far from domesticated. He may consort with one doe for a little while, but he soon seeks another.

The quick beating of the heart, the rapid breathing movements, and the tremulousness of the long ears, have suggested the epithet " fearful," but one may doubt whether there is much fear in the hare's composition. It is extraordinarily alert ; it understands the wisdom of lying low ; it takes no needless risks except in March. On the whole, the hare presents a brave front to persecution, and it

utters its poignant cry only when there is no possibility of escape.

The contrasts between hares and rabbits are many, and there is no love lost between the two species. It is plain that the hare has been specialised for a much more adventurous life, and in connection with the giving-up of the burrowing habit (of which, however, there are interesting reminiscences) the leverets are born furry and open-eyed—impatient to leave the nest—very different from the naked young of rabbits.

In many countries the hare has become the type of alertness and astuteness, and the first of these qualities is certainly characteristic. Although it does not sleep with its eyes open, it is rarely to be caught napping ; it seems always in training, and we have never seen any fat in the usual place below the skin.

THE RABBIT

The rabbit suffers from having such a distinguished relative as the hare, but it has its own points. It must have a good constitution to be able to stand importation to climates so different as those of Scotland and Australia. And it thrives in Ireland, though not in cold countries like Scandinavia. There is little doubt that for many centuries after the Ice Age there were no rabbits in Britain. They seem to have come over with the Conqueror, for their headquarters in post-glacial times were Mediterranean and Iberian.

To some extent the rabbit succeeds because it multiplies so rapidly. It works with a large margin. This is not a high virtue, for low-grade fishes can spawn by the million ; but it stands for something. It means a certain kind of vigour, even if it be exemplified in the millions of mites that frequent the great cavern of the over-dry Stilton cheese. Now a rabbit may have four to eight litters in a year ; the period of life before birth is just under a month ; there are three to eight young ones in each litter ; and the young rabbits are ready to multiply in half a year. This is almost like "spawning," and since the rabbit's infantile

mortality is not very high, the great fertility means a rapid increase of population.

No one can call the rabbit a clever animal, and whoever "Brer Rabbit" was, he was not our *Lepus cuniculus*. In many countries he was certainly the astute and resourceful hare; in North America he was probably a Cottontail (Sylvilagus). Yet the rabbit has its gifts—keen scent, a considerable degree of alertness, sociality, and a pleasant playfulness of an evening. It is not courageous in the presence of its enemies, such as fox and stoat, buzzard and owl, but a furious mother will occasionally fight for her offspring. A rabbit may even bite a dog! There is something very ineffective in the fear-paralysis which sometimes besets a rabbit when it looks round and sees the stoat on its heels: it stops running and starts screaming. There is a pleasanter suggestion in the way the seniors flick up their white tails when danger threatens in the dusk, thus giving the youngsters a lead in finding the burrow as quickly as possible.

There are records of pairs of rabbits which remain together for a year at least, but this is not the way with the majority. Their morals are of the loosest. Rodier's plan of dealing with the Australian rabbit pest was to kill as many does as possible, but no bucks. The local result was that the bucks killed the helpless young, and the disproportion between males and females became so great that the females perished. But in the immense areas of Australia the only hope of permanent relief from a gratuitous tangle in the web of life (rabbits were introduced about 1860) seems to be the increase of the agricultural population.

To the rabbit's credit we must also place its domesticability. Not only does it breed well in artificial conditions, but it has proved itself a fountain of change. It has given origin to a multitude of varieties—the popular "Belgian Hare" (sometimes accepted by the credulous as a cross between hare and rabbit), the small Dutch and the Flemish giants, the beautiful Angoras, often like mops of silky white hair, the quaint Lop-Ears with the ear-trumpets spread out on the ground on each side of the head, the Himalayans

and Patagonians and Siberians and Black-and-Tans! Numerous " factors " or hereditary items go to make up the beautifully coloured coat of the wild rabbit; when one of these drops out of the inheritance there is a colour-variety, when two drop out there is another colour-variety, and so forth, with the result that we have blacks and whites, yellows and " blues," and other colour-varieties, not to speak of tortoise-shells. When these varieties inter-breed there is in the offspring a reappearance of the wild-rabbit type, not through any mysterious " reversion," but simply because there is a *re-combination* of the peculiarities which have arisen by sifting apart the various components of the original wild complex. When the components re-combine the coat of the wild rabbit reappears.

We get a useful picture of what a different species means in Natural History when we contrast the rabbit and the hare. The rabbit has shorter feet and it runs in a different way; it has shorter ears and there is little hint of the hare's black tip; it is gregarious and normally a burrower, while the hare is solitary and rests in an open " form "; its young are born naked and remain blind for eleven days, whereas those of the hare are born furry and open-eyed; its danger-signal is thumping with the hind-legs, whereas the hare grinds its front teeth against one another; the rabbit is much more prolific than the hare, with a much wider range of appetite, with a different voice, a different coloration, and a different temperament. Its flesh has an entirely different taste. It is not surprising to find that hare and rabbit are incompatibles. They are not known to be capable of inter-breeding and the fastidious hare leaves the pasture which the rabbit has fouled. The hare is altogether more of a gentleman!

Many are the points at which the circle of the rabbit's life cuts into man's. Rabbits destroy crops and young trees; but they afford pleasant food and fur. Rabbits turn fertile land into a desert; but they make the most effective golfing turf in the world. They assist in the education of the medical student and in the training of the shot. And Bunny has done much for the human child.

THE BADGER

Among the native British hillside animals we can still include the badger—a creature of long pedigree, that lingers in our midst in spite of heavy odds. In some parts of the country, such as the New Forest and Devon, it still has a firm foothold; but, on the whole, it is surviving and no more. That it was once much commoner is proved by the number of place-names such as Brockhurst, for Brock means badger. The question arises how this big animal holds its own at all in a country where agriculture spreads and woodland shrinks, and where the desire to kill anything strange and interesting seems almost ineradicable. How does the badger survive? In the first place it has become nocturnal—a creature of the shadows, with a strong instinct for self-effacement. Even after dusk it will work its way down a dry ditch or along the side of a hedgerow rather than cross the open. The variegated grey colour of its fur favours invisibility, and the striking white bands on its head are much less conspicuous at night than during the day.

Moreover, the badger has strong virtues of its own. It is a very muscular animal, with a first-class heart and circulation, and a good wind. The lower jaw works in a socket so deep that dislocation is almost impossible, and the grip is unsurpassed in tenacity. Its thick coat helps the badger to withstand the cold of winter, and it also stores a good deal of fat. Furthermore, it is endowed with keen senses, shrewd intelligence, and a capacity for taking things easily. It is more alert than it looks, it is at once cautious and cunning, it is dogged without being obstinate, and it does not fuss or worry. It is a creature with a great deal of character and strong idiosyncrasies.

Again, like the otter, the badger has an extraordinary catholicity of appetite, which is always an advantage in the struggle for existence. If one kind of food fails, it can fall back on something else—roots and fruits, worms and grubs, frogs and snakes, eggs and young rabbits, the larvæ

in the wasps' nest, and the honey in the humble-bee's, and much more besides. Another factor in survival is to be found in the burrowing habit, for it is always advantageous for a terrestrial animal to get off the surface of the earth, whether up a tree or underground. The "earth" or "set" on the copse-covered hillside or in the recesses of a wood has tortuous passages which often go far in; there may be several entrances, and one burrow may communicate with another.

Careful observers seem to be unanimous in commending the badger's sanitary arrangements. It wipes its feet before going indoors, and it does not foul its set. There is a big spring-cleaning before the in-lying time, and another after that anxious period is over. Some naturalists have had the good fortune to see the badger carrying to the warren a huge bundle of bracken and dry grass, wherewith to replace the bedding that has been rejected. The badger is neither foul nor surly.

Sometimes the safety is increased by the seclusion of the home, away on the top of the heather-covered hill, where a cairn may afford shelter, and where no enemies intrude. The badger shares such solitudes with the Mountain Hare and the Ptarmigan; the only disadvantage is that the seclusion implies a somewhat ascetic menu and many a long mile of heavy walking in search of food. A badger may go six miles of a night.

We are inclined to attach great survival value to the education which the mother badger gives to her silvery-grey cubs. There are usually just two or three of them, born in spring, after an ante-natal life of perhaps twenty-two weeks (but this is a subject regarding which there is extraordinary discrepancy). When they have got their sight, some nine or ten days after birth, and had the usual gastric education on milk, they are taken outside the warren and well-groomed. But then comes schooling, and the mother is a stern disciplinarian. She punishes the inattentive and foolhardy cubs, and gradually instructs them in the long alphabet of woodcraft.

A badger is a thick-set, round-backed, rather bear-like

carnivore, somewhat over two feet in length, with an additional seven inches to the tail. It has a long muzzle, well-suited for its restlessly inquisitive poking into holes and corners; the small, round ears are not in the way among the brushwood; the bluish-black eyes leave nothing to be desired in brightness. The heavy body does not seem to be lifted much off the ground, the snout is often held low, the soles of the feet are entirely on the ground in true plantigrade fashion. Nevertheless the movements are easy and stealthy, and the creature does not know what it is to be tired. There is a peculiar odoriferous gland under the tail, which may possibly enable badgers to keep up their acquaintanceships. Badgers growl when angry and chuckle when cheerful, and the husband and wife have a good deal to say to one another in a somewhat stoat-like chatter. Those who have the privilege of knowing badgers intimately, speak of their playfulness and of the dislike the male has to find the female sleeping when he is busy, and conversely! It is quite certain that badgers do not hibernate, though they may doze through days of compulsory fasting. Their severest trials must be when the ground is covered with snow, and their activity then is evident enough from their characteristic spoors.

An elusive creature with a strong individuality readily becomes the centre of myths, and one of the strangest concerning the badger is that the limbs on one side of the body are shorter than those on the other—this being an adaptation to movement *along* the hill-slopes. A wonderful adaptation, indeed, forcing the creature, however, to be very uncomfortable when it turns homewards again! But perhaps "the uneven badger" always makes a circuit! The badger does not need the lies of men, but it could do with a little more admiration. For this old-fashioned creature of the shadows is a precious legacy from distant days and should be held in due respect. Perhaps we are growing a little more appreciative, for we do not go in for the badger baiting our forefathers enjoyed.

THE POLE-CAT

This attractive member of our dwindling mammalian fauna is one of the bear-badger-otter-stoat tribe of Carnivores, and has nothing to do with any cat, large or small, wild or tame. It is Arctoid, not Feline. It is easily known by its size, for the male is about two feet long, including seven to nine inches of tail ; and the female is almost one-third less. The long, dark, coarse outer hairs, which probably help to throw off the rain, hide the yellowish under fur. What the word polecat means seems very uncertain, but the alias "foumart" is probably an abbreviation of foul-marten. Another name is fitchet.

The polecat is widely distributed in North Europe, and our cave deposits show that it was an ancient (early Pliocene) British mammal. It was doubtless exterminated during the Ice Ages, and found its way back again from the Continent before the insulation of Great Britain. Now it is approaching extermination again, for it is very rare south of the Caledonian Canal. The reasons for this disappearance of an interesting relic are to be found in the extension of arable land, in the severity with which the polecat is persecuted by gamekeepers and poultrykeepers, and also in a certain recklessness which leads the animal to use the same run over and over again—a mistake the otter rarely makes. It would not have survived so long had it not been in great part nocturnal in its hunting, and had it not been able to utilise a great variety of food. During the day it usually rests in a thicket or in a borrowed burrow, in a little cave or in the recesses of a wood-stack, or about a ruined cottage. Under cover of darkness it moves quietly about with great agility and defiant courage.

What flesh will it not eat ? It is able to take eels from the river or pond, for it is a good swimmer ; it condescends to frogs from the marsh ; it is clever enough to kill snakes, and it is said to be immune to the adder's poison. It sucks the eggs of birds that nest on the ground, and it follows rabbits into their burrows. To its credit must be put its destruction of rats and mice ; against it are its depredations

in the poultry-yard. It bites a biggish animal behind the ear or in the throat, and it is said to relish the gush of blood from the jugular vein. A smaller victim is bitten through the skull, and the brain is said to be a titbit. In the majority of cases the booty is carried to the lair and enjoyed at leisure and in safety; but the creature sometimes satisfies its hunger on the spot. And what makes the polecat's depredations so serious is a sort of Berserker fury which leads it to kill and kill beyond all possibilities of utilisation. We suppose that an instinctive killing impulse is activated which cannot stop as long as there is any victim left to be slain. Such an opportunity as a hen-house offers is obviously not one that has many counterparts in Wild Nature, and the polecat makes the most of it. No one can be surprised at the persecution which has made the polecat a rarity, yet the animal has its usefulness as a check on the prolific multiplication of rats, mice, voles, and rabbits, and as an eliminator which tends to weed out the weaker individuals first, and thus improve the vigour of a stock like that of grouse.

In addition to this useful pruning and sifting, which is part of the process of natural selection, the polecat is a creature that demands our admiration for its litheness, its indefatigability, and its courage. Like the stoat, it is almost without a trace of fear in its composition. It is nervous, but not timid, and it will attack a full-grown hare, a turkey, a goose, or, in desperation, man himself. It is very strong in neck and limb, and the skull (of the male in particular) is a little masterpiece. The polecat has great tenacity of life, and it seems a pity that a creature with so many virtues should dwindle before man's artificialities.

The male is called the "Hob" and the female the "Jill," and their pairing time is towards the end of winter. Four to six young ones are born in May or June, blind and helpless and with buff-white fur. There is usually a "but and a ben" in the retreat, the one for storage and the other a living-room. The offspring are carefully nurtured, and they begin to be educated out of doors when about six weeks old. In another month the mother ceases to suckle, and the youngsters are left to fend for themselves

which they are thoroughly capable of doing. It may be mentioned that the "Jill" puts on an entirely new suit of fur after her maternity, and the "Hob" changes his in a more leisurely way a little later in the year. He is then known as the "Black Ferret." As to the fetid smell to which the name "foul-marten" refers, it is, in part at least, a protective quality, and it is not much in evidence unless the animals are irritated or in extreme danger. The malodorous fluid comes from two special glands at the end of the food-canal, and it is almost as repulsive as the similar secretion of the skunk.

It is generally believed that the ferret is a domesticated variety of the polecat (*Mustela putorius*), but this is not quite so certain as is usually stated. One great authority, Mr. G. S. Miller, maintains that the ferret is more nearly related to *Mustela eversmanni*, a species found in Western and Northern Asia. Most ferrets are albinos, that is to say, the hereditary "factors" for colouring or pigmentation have dropped out of the inheritance. Thus, the fur is cream-coloured and the eyes are pink, the red blood shining through an unpigmented iris. But there are also dark-coloured ferrets which are very like polecats, though there are some notable differences in the skull and in the fur. The ferret is also a hardier and less "nervous" animal. Miss Frances Pitt writes :

"In such intangible peculiarities as temperament and disposition the ferret is very different from the polecat, as is shown by the ease with which it is tamed even after being neglected while young. An adult-caught polecat is quite untamable, and even half-bred ones require constant handling from their earliest youth to make them docile. It takes a very serious fright to make a placid, easy-going ferret emit the vile defensive odour, but the hybrids never hesitate to make use of it. In disease-resistance, too, the ferret differs from the polecat, being less susceptible than the wild animal to some of the diseases met with in captivity" (*Journal of Genetics*, September 1921). On the whole, Miss Pitt's facts seem against the view that the ferret is a domesticated variety of the British polecat. The ferret crosses

readily with the polecat, and the hybrids are fertile among themselves and with either parent. The first crosses show complete, or almost complete, dominance of the polecat type as regards outward appearance, but in skull characters the ferret is dominant.

One is all too apt to think of evolution as something that occurred in the past only, instead of realising that it is going on now. A good example may be found in the "red" polecats which have been cropping up recently in Cardiganshire. The "red" variety occurs among ferrets as well as among polecats, and is probably due to the dropping out of one of the hereditary "factors" determining the normal colouring. When red varieties are crossed with white ferrets, all the offspring of the first generation are red, or, to put it in Mendelian language, redness is *dominant* to whiteness. But if red varieties are crossed with black-brown varieties, all the offspring of the first generation are black-brown. In other words, red is *recessive* to black-brown. In both ferrets and polecats the redness is associated with large size, and in the ferret at least it is usually accompanied by a quick temper and a general increase of vitality. Here we have plainly to deal with a new departure, at present manifesting itself in Wales, and quite likely to gain a firm foothold. Evolution is going on.

Crosses between ferret and wild polecat are said to be very effective for work in a rabbit warren; and this is especially true of the immature young females, which are very agile. Dark varieties that escape and become feral are apt to be confused with pure-bred wild polecats. We cannot pass from ferrets without recalling Sir John Millais' story of the big man for whom the doctor had prescribed leeches. "These little worm things!" his wife exclaimed. "I put a ferret on him."

THE DORMOUSE

As a type of the true hibernators or winter-sleepers we take the dormouse (*Muscardinus avellanarius*), an attractive member of the order of Rodents or gnawers. It is in

October that the dormouse usually passes into the state of winter-sleep, and it remains hibernating till April. It is very fat when it betakes itself to a well-lined nest in a mossy bank or in a tree-stump; it is lean when it reawakens. In its comfortable nest the "sleeping-mouse" lies for half the year, with its tail wrapped round its head and back, and with its paws on its cheeks. In very mild weather it may rouse itself and eat a little (there is often a store of food in the nest); but normally the hibernation is continuous. Sudden coercive awakening may be fatal. To the soundness of the slumbers the name of dormouse (*dormir*, to sleep) plainly refers; and Shakespeare speaks of awakening "your dormouse valour." Many of its other names are pleasant, like "dory-mouse" and "sleepy mouse." So is "chestle-crumb," but we do not know what it means.

The dormouse occupies a position somewhere between squirrels and mice. Some of its features are: the compact body about three and a half inches long in head and trunk, the thick-haired slightly prehensile tail with a length of over two inches, the thick, soft, yellowish hair, the prominent eyes, the blunt snout, the rudimentary thumb and short first toe, the small but very strong claws well suited for climbing. It is widespread in England, but does not occur in Scotland or Ireland. It belongs to an old-fashioned stock, confined to the Old World, and established before Japan was separated from China, or Africa from Europe.

A timid, gentle creature, "the squirrel of the thickets," very clever in making its way in the dense undergrowth. It sleeps for the greater part of the day in a dormitory of grass, moss, and leaves, not usually far off the ground. In the dusk or at night it hunts for nuts and berries, acorns and grain, and occasionally small animals. When eating it usually sits on its haunches, and holds the food to its mouth; but it can also enjoy its food hanging head downwards by its toes. There is safety in its tangled habitat, in its quick movements, and in its avoidance of the light of day. It seems to be a very silent creature, making scarce a sound save a slight hiss when frightened. One of its few near relatives, the garden-dormouse (*Eliomys*) of the

Continent, has been known to avoid capture by surrendering its tail in lizard-like fashion. This is a very remarkable occurrence in a mammal, and its efficacy is increased by the capacity for replacing what has been lost. A tail for a life is a useful jettison. But this is not known in the Common Dormouse (*Muscardinus avellanarius*), whose second name refers to a supposed fondness for filberts or hazel-nuts. In this country it is just as fond of the tart fruit of the rowan-tree or mountain-ash.

The dormouse seems to be monogamous, and though there may be a number of summer dormitories near one another, the inmates keep themselves to themselves. When her time comes the female makes a nest separate from the dormitory and rather larger (about six inches in diameter), and there, after a short ante-natal life of three weeks or so, the young ones are born. Four is a common number, and there may be two or more families in the season. The young ones are born naked, with closed eyes and ears, and they certainly need a nest. The young dormice have to be nurtured in the nest for about three weeks before they are able to fend for themselves. An interesting point is that the members of a family born late in the year are likely to perish. There is not time for proper nurture before the mother sinks into hibernation, and it seems to be a condition of successful hibernation in dormice that a considerable quantity of fat is accumulated before the animals begin to lie low. It should be mentioned that the winter dormitory is often underground and that the dormouse "sleeps" alone. Dormice may live for three or four years in pleasant captivity—one of the conditions being that the atmosphere of their home is not allowed to become too dry even in winter. It may also be useful to mention that dormice like plenty of water to drink. They are not very "brainy" animals, but they are very attractive, and they have no smell.

The question rises, how do these timid, gentle, inoffensive creatures hold their own in Wild Nature? As we have indicated, the answer must be found in their elusive ways—living in thickets and active at night, in their alertness of

sense and adroitness of movement, in their long bill of fare, in their careful mothering of numerous families, and in the capacity for "winter-sleep." As a matter of fact, dormice have few enemies; and even the owl may be a friend in disguise, for it will be most likely to catch those that are dull or careless. A race of animals is always the better of some sifting, and the same applies to mankind. "Behold the life of ease, it *drifts*," as George Meredith said.

MICE

If we consider house mice apart from the damage they do, we must admit their attractiveness. They are neatly built, pleasant in colour, smart in their movements, alert in most of their senses, and as clever as they need to be. If we consider them economically we must use the word *pest*. For they devour enormous quantities of food, they spoil more by their droppings, they destroy useful things like clothes and books, they gnaw their way through partitions and floors, they have an unpleasant odour, and, if they get the upper hand, they may cause a veritable plague.

The common mouse, or house mouse (*Mus musculus*), is now almost cosmopolitan, but it probably came to Europe from the East not earlier than Neolithic times, when man began making a better class of stone implements. It has been with us so long that it has established local races or new species in St. Kilda and the Faeroes. It is very variable in its colouring and plastic in its habits, for the country mouse and the town mouse are the same species! Perhaps there is nothing they will not eat or chew, from cheese to lead pencils, from the stores of the beehive to the seaweed on the shore. Even tobacco is not refused. An individual mouse is not unpleasant, especially when it sings in the evening; two or three may be smiled at; but when they become numerous they are intolerable. It is not merely that they devour materials and make nests of important papers, there is danger in their contamination of food, and they are vehicles of serious parasites like the trichina-worm and the microbe of the plague. There is no modera-

tion in their productivity. They may be parents before they are a year old; they carry their young before birth for only three weeks; they may have half a dozen litters in the year; and there are usually five or six in a litter. A little one soon becomes a thousand! The desirable checks are, of course, to keep foodstuffs well covered, to be careful with crumbs, to give hospitality to a good "mouser," and to use traps before a pest becomes a plague. It is sometimes forgotten that if we greatly reduce the number of rats, which is most desirable, we are bound to increase the number of mice; therefore measures must be taken which are checks *to both*.

The field mouse or wood mouse (*Apodemus sylvaticus*) is the most abundant and most widely distributed of European mammals, and occurs in all sorts of places from sea-level to far up the mountains. It differs from a house mouse in its much longer hind-legs, larger hind-feet and ears, and larger, more bulging eyes. It is a hardy, alert, versatile animal, with a good many accomplishments—"a fine jumper, a good climber, a capable digger, and a fair swimmer." As its prominent eyes suggest, it is in the main nocturnal. It bounds about in an unpredictable sort of way, and Messrs. Barrett-Hamilton and Hinton note that "at all times, even when it walks, its long hind feet give it a characteristic 'action' in moving about, which is probably its most peculiar feature." One has been known to leap down fifteen feet and proceed unhurt, which says a good deal for its elasticity of limb.

Mainly a vegetarian, it has a very wide range of appetite—grain, fruits, roots, leaves, and even flowers. Many people are sadly aware of its fondness for crocus corms and hyacinth bulbs. In many cases it has been known to eat insects, and the burglary of a beehive has been occasionally reported. It is very rarely that field mice enter a house, though they may draw to the farmyard in the winter. As Virgil noted, the *exiguus mus* makes stores, which usually consist of grain, and it falls back on these reserves when the weather is very severe. There is no true hibernation.

Rodents, as every one knows, are extraordinarily prolific,

but it is probable that the field mouse beats them all. Females will breed at five months old, and one has been known to have five families between the beginning of March and the month of July. Four or five is the commonest number in a litter. Gilbert White and others have called attention to the way in which the young ones cling to their mother's teats or even to her hair, so that she can carry them for a short distance if the nest or burrow has been suddenly disturbed. The mother field mouse is certainly a very thoroughgoing mammal, and the story goes that when several families live together, as they sometimes do, she does not mind whether the children she nurses are her own or not. But these maternal virtues are not much appreciated by the farmer, and it is some satisfaction to know that field mice have many enemies—all the beasts and birds of prey. If creatures like weasels and owls were left alone, the balance of Nature as regards field mice would be steady enough.

The Field Vole belongs not only to a different genus (*Microtus*), but to a different sub-family (Microtinæ); we have been discussing *Mus musculus* (the house mouse) and *Apodemus sylvaticus* (the field or wood mouse) in the sub-family (Murinæ). There are four other kinds of field mouse in Britain, the Hebridean, the St. Kilda, the Fair Isle, and De Winton's yellow-necked field mouse. Those from the islands are interesting as examples of the origin of new species in isolation.

But we have another and delightful mouse, the harvest mouse or *Micromys minutus*, which has found its particular niche of opportunity among the corn and the tall grasses. It is a pigmy, coming next to the pigmy shrew, which is the smallest of British mammals, about two and a half inches in body length and two inches more for the tail. Its weight (about a fifth of an ounce) is just a sixth of that of the field mouse. As Gilbert White put it in his graphic way, " Two of them in a scale weighed down just one copper halfpenny." It can poise itself on an ear of wheat! It is interesting to notice how this pretty rodent is particularly suited for its habitat among the corn. It is the only British mammal with a prehensile tail, and it can actually hang free

for a second or so. The hands and feet are relatively large, and they bear pads which greatly help the acrobat in its climbing. Unlike the field mouse, it is most active during the day. Both for its own comfort and for the rearing of its frequent families it makes a ball-like nest of plaited grass leaves, fastening the structure to growing corn or to ranker vegetation. As many as a hundred leaves may be used in the construction. There are often special winter nests, sometimes underground and sometimes among the reeds; but if the harvest mouse can get inside a stack, that serves its purpose well. There is no true hibernation, but in many cases there is some storing of grain for the winter. The everyday food consists of seeds and insects, and is very varied. When eating a grain of wheat the harvest mouse sits up like a squirrel, holds the grain horizontally between its two hands, and revolves it rapidly till it has bitten off the outer envelope and got at the real thing. A dainty creature! We can well believe that it makes an interesting pet, and it has this further recommendation that, like the field mouse, it is without the characteristic odour of the alien *Mus*, which does not belong to Britain at all.

VOLES

The little Field Vole (*Microtus agrestis*) is representative of those animals that are hostile to man by interfering with his agricultural operations. Small animals are much more likely to be detrimental than large ones, partly because they usually multiply much more rapidly, and partly because it is easier for them to escape capture. The Field Vole is a case in point. The length of the head and body of a mature male is only about four inches (the female a third of an inch less), and the tail does not exceed an inch and a half. So we have to deal with a very small animal, as compared with a rat, for instance. But against the small size we have to weigh the multitudinous numbers, for there are three or four litters in the year, with an average number of five young ones each time. Thus they tend to become very abundant and then the grass begins to suffer. Since that is their



Photo: Frances Pitt.

LONG-TAILED FIELD MOUSE (*Mus sylvaticus* or *Apodemus sylvaticus*).

This common mouse, badly called wood mouse, is slightly larger than the house mouse, with a longer tail, and with longer hind-feet, which are white in colour. It roams in summer and seeks the farm steadings in winter. One knows that it is not a vole by the prominent ears and the narrowed muzzle.

favourite food, there is much to be said for the commonest of the popular names for the little creatures, namely, "grass mice."

Many authorities distinguish the Highland Field Vole or Grass Mouse (*Microtus agrestis*) from the Common Field Vole or Grass Mouse (*Microtus hirtus*) which is the common species in England and the Scottish Lowlands. The former represents the older stock, but the two kinds are very nearly

related and may be considered together. Once the splitting up of kinds or species begins, it is difficult to know where to stop.

Field Voles are usually either russet-brown or greyish-brown above and greyish-white below, but there is considerable variability in the colouring. In many cases it is well suited to hide the animals against the background of the soil, serving as a " cloak of invisibility." When we look at a Field Vole we notice at once the blunt muzzle, the broad head, the inconspicuous ears almost buried in the fur (so different from the upstanding ears of a mouse !), the short hairy tail. When we look more closely we notice the moderately hairy soles of the feet, the six or seven naked pads, a sharp nail on the minute thumb, the two strong chisel-edged front teeth (incisors), the three cheek-teeth (molars) which continue growing throughout life as they get worn away on the surface. It is worth looking for a skull that the ants have cleaned, for then we can more readily examine the structure of the teeth with a lens, and observe, for instance, the neat little zigzag triangles of enamel on the crown of the molars.

Field Voles are gregarious and companionable, but they show no co-operation or social life in the strict sense. They frequent pastures, arable lands, bents, moors, plantations, hedgerows, and similar places from Cornwall to Caithness, and in Europe generally. But they do not occur in Ireland. The food they like best is what they find in the succulent bases of grass stems, but they have a wide range of appetite for shoots and roots, fallen corn and leaves, even bark when the worst comes to the worst. The chisel-edged incisors are well suited for slicing and gnawing, and the back teeth for making pulp.

Field Voles work by night as well as by day, and all the year round. If the frost is very severe they may fall " asleep " for several days, but they should never be called hibernators. Sometimes they lay up stores for hard times, but this does not seem to be common or necessary in Britain. At all times the appetite of these Rodents is enormous and they require a good deal of water. They make runs on or

just under the surface, and these often intersect in a complicated way, so that a plan reminds one of the streets of a town. One and the same run may be above ground at one place and under ground at another. The runs seem to be common property. At other times the Field Voles make deeper burrows to get at roots or to form a nursery in cold weather, but they are not in any special way suited for burrowing, as moles are, or for climbing, like harvest-mice. They run smartly, without bounding, and they do not bite when they are caught. They are good swimmers. They probably sleep a good deal between meals, but they sleep lightly. They are careful in keeping their fur in good order—as careful as cats ; and they have also cleanly ways of disposing of their ordure. Their voice, used when they are excited or hungry, is " half a grumble, half a squeak."

As to family affairs, it seems that the Field Mice live together in pairs, but there is some indication that there are many more males than females. We do not know enough to tell whether they are monogamous in actual fact. The breeding begins in April and may continue till winter, three or four litters being common. The offspring are often between three and six, but there may be litters of ten when food is very abundant and the weather very genial. The female has eight teats. The life before birth is believed to last for about twenty-four days, and a mother suckling her offspring is often at the same time with young. All this points to the possibility of rapid multiplication, but it should be noted that the Field Vole is not nearly so prolific as the mouse or the rat. Mr. Barrett-Hamilton notes in his fine *History of British Mammals*, that in captivity the male may be safely left with his family, though he will devour strange litters. This points in the direction of genuine monogamy.

From ancient times " vole plagues " have been known, and one may recall the defeat of Sennacherib's army owing to the innumerable voles that came by night and gnawed away all the quivers, arrows, and bowstrings. The last British " plague " on a big scale was in 1891–93, when large areas in the South of Scotland were turned into desert.

Mild weather brings about an abundance of grassy food, and the voles have large litters. Beasts and birds of prey have their innings, and they also multiply more than usual; but they cannot stay the tide of rodent life. Gradually the grass gets scarcer and the Field Voles take to unusual ways



Photo: W. S. Berridge, F.Z.S.

FIELD VOLE (*Microtus agrestis*).

The common short-tailed field vole or field mouse ranges all over England and Scotland, but does not occur in Ireland. It does a great deal of damage by eating all sorts of crops, and it stores in its burrow for the winter. So it is fed at the farmers' expense all the year round.

of feeding, such as barking the trees and gnawing at their roots. Sooner or later, however, famine sets in among the voles; fertility drops; some disease occasionally gets a grip; the numbers sink to a minimum; the vegetation begins to show face again—the plague is over. But much damage to agriculture is often done before the balance is restored.

It is usual to refer " mouse years " to two causes—unusually mild and moist weather, on the one hand, and a destruction of natural enemies on the other. There is no doubt that both these causes will tend to favour the increase of voles, but it is quite possible that there is some obscure factor producing a natural cycle. Plagues have occurred in places where there was no game-preserving reduction of the beasts and birds of prey; and the facts do not seem to warrant more than a cautious statement to the effect that great reduction in the number of natural checks will tend to a great increase in the number of voles. Among the natural checks we may mention weasels, stoats, foxes, owls, kestrels, crows, and rooks.

It cannot be said that man has been very successful in combating vole plagues. Vigorous use has been made of poisons, infection with a microbe, burning out, hunting with dogs, flooding, trapping, and making numerous pitfalls much broader at the bottom than at the mouth, so that the voles cannot climb up the overhanging walls. One of the safest poisons to use is a mixture of red squill powder and oatmeal.

It is probable that " vole-plagues " on a small scale are not infrequent, and it is common sense to try to nip these in the bud, so to speak. A serious vole-plague is so costly that its beginnings should be carefully watched. Besides the judicious encouragement of the natural enemies already mentioned, there is the counteractive of destroying rough grasses about hedges and field-margins and waste places *in the vicinity of pasture*. This tends to rob the Field Voles of part of their shelter and to expose them to hungry eyes. In a deep sense it may be said that the better the agriculture, the fewer voles there will be.

On three counts at least there is a strong case against Field Voles. First, they destroy the pasture by eating the bases of the grass stems. They sometimes do similar damage in corn-fields, and they are fond of clover leaves and the like. Secondly, their networks of tunnels underneath the surface of the ground may seriously disturb seed beds and young roots. Thus they do much damage in disturbing

as well as in devouring. Their tough summer nests, made of dried grass, are sometimes troublesome to the reaping machines. Thirdly, they often " ring " young trees, cutting off the bark just above the ground. They may also nibble through the roots. A common preventive is to surround the base of the tree with a cylinder of wire netting of narrow mesh, pressing the lower edge of the cylinder well into the ground. A poison wash of strychnia sulphate mixed with starch and glycerine may also be brushed on to the base of the tree.

The circle of the Field Vole's life cuts many other circles, such as those of grasses, weasels, kestrels, and man. Charles Darwin was probably referring to Field Voles in his story of the " field mice " which destroy the combs and nests of humble-bees, and thus lessen the useful work of these insects in pollinating the red clover. Field Mice also destroy a destructive sawfly that attacks the larch.

Much less important from the agricultural point of view is the Bank Vole (*Evotomys glareolus*), a rather smaller animal than the Field Vole, ruddier above and whiter below, with slightly longer ears and tail. Its cheek teeth are rooted in the adult, which never happens in the Field Vole. It likes sheltered dry places, and often finds its way into gardens, where it attacks bulbs and newly sown beans and peas. It also does much harm in plantations. As it works chiefly at night it is seldom seen. It does not seem to multiply so quickly as the Field Vole, and that is something to be thankful for.

Every one delights to call the water vole the water rat, for this never fails to annoy the zoologist. We confess that it always seems to us a little pedantic to try to alter a name that is almost universal. The only important point is that the water rat is *not* a rat. At a glance one sees several differences: the body is more robust, the head is more rounded, the muzzle is blunt, the ears scarcely show above the fur, the eyes are much smaller, and the tail is hairy and much shorter. When the glance becomes a scrutiny, deeper differences appear, and one is bound to admit that the " Water Rat," *Arvicola amphibius*, is not a rat! For a rat

has a much narrower head and snout, much larger ears and eyes, and a longer tail nearly naked, besides, of course, more technical peculiarities.

Yet it is well, we must admit, to emphasise the fact that the water rat is a vole, for this gives us the key to the whole situation. The creature is a large-sized vole that has circumvented the severity of the terrestrial struggle for existence by becoming in great measure aquatic. It is large and palatable, so it has taken refuge in the water! No doubt this partial change of habitat has meant new enemies, such as the heron and the pike, and new dangers, such as floods and frost, but it has worked well on the whole, and the genus of water vole is represented from the Scottish Highlands to the Altai Mountains, from the South of France to the shores of the Arctic Ocean. But our British species, *Arvicola amphibius*, is confined to this country, not including Ireland. There is a brown variety, commoner in the south, and a glossy black variety, commoner in the north. It often wanders at night in search of succulent food, and as things look big in the dusk, it is sometimes called the "earth-hound." It is credited with visiting graveyards by night, but this is just a picturesque touch, with no justification save that the Water Vole is a rover. It has been seen in Scotland 2000 feet up among the hills. It is by no means a nocturnal creature in the strict sense.

One cannot say that the Water Vole is in any special way adapted to aquatic life, except that the ear-valves are well developed, the coat is thick and not easily wetted, the feet are slightly fringed though not webbed, and the long tail may help in steering. The creature swims and dives admirably, but it shows itself an evolutionary newcomer in habitually, though not invariably, using hind-feet as well as fore-feet in swimming, as non-aquatic mammals do when tumbled into the water, and in showing much of its head and back above the surface. On the other hand, the young ones are able to swim very early, even before they can see. The important point is this, that while keeping one foot, as it were, on land, the Water Vole has secured relative safety by discovering the resources of ponds and sluggish streams.

But more important than any of the slight adaptations in structure is the nature of the burrow that is excavated in the bank. For while it is sometimes rough and ready, it almost always has one entrance at or under the water level and another on the land side. Sometimes the burrow has several under-water entrances and several branches with chambers. In one of these the young ones are sometimes nurtured, but well-hidden surface nests, made of reeds and grasses and away from the burrow, seem to be commoner.

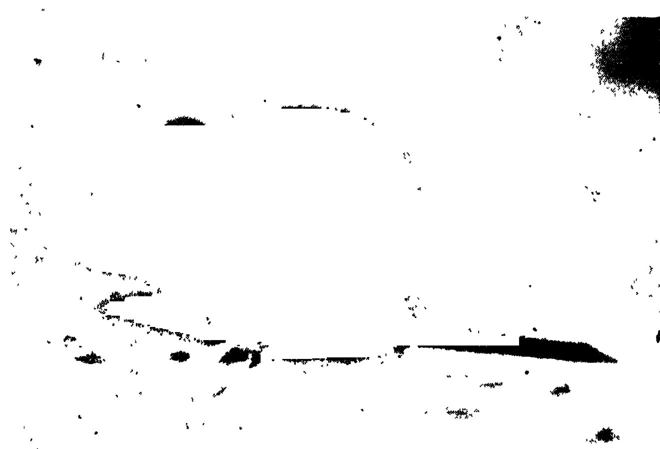


Photo: W. S. Berridge, F.Z.S.

COMMON BANK VOLE (*Evotomys glareolus*).

This relative of the field vole has a tinge of chestnut in its upper fur, and it is therefore often called the red field mouse. A deeper difference is that the cheek teeth develop roots in the full-grown animal, which is never the case with the field vole.

There are three to eight young ones in a litter, and there may be two litters in a year. The young ones are born with their eyes shut, but not very helpless. In many cases the mother has been seen transporting them by water from a threatened nest. She grips the young one in her mouth and presses it under her throat, swimming and diving without embarrassment. Thus we see that maternal care is one of the factors in securing survival.

Another advantage, shared by many other animals, is the long bill of fare. This always counts for much, for it is of survival-value to be able to thrive on many different kinds of food. This is certainly true of the water vole. Predominantly vegetarian, it must be ranked as potentially omnivorous. All is grist that comes to its mill—roots and shoots, leaves and bark, turnips and potatoes, water-lilies and horse-tails, nuts and haws, earthworms and dead trout, mussels and crayfishes, and stranger things still. Yet after we admit that Water Voles cannot be acquitted from the charge of damaging osiers or of breaking down the banks of streams, we cannot say that they do much harm to man's crops or property, or to his trout-fishing. There does not seem to be good evidence of any storing habit in British water voles, and it need hardly be said that they do not hibernate. A creature that can burrow for roots and swim about under the ice is not likely to be much inconvenienced by a British winter. We cannot leave its feeding habits without recalling the pleasant picture one sometimes sees of the Water Vole enjoying its meal just outside the doorway of its burrow or on a half-floating platform of rushes and waterweed. It usually sits upright like a squirrel and nibbles neatly at the piece of root or shoot which it holds in its paws.

Rather against the Water Vole's success in life, one would think, is its short-sightedness, but there is little evidence that this is a serious handicap in the ordinary conditions of its life. Against the poor sight may be balanced the advantage afforded by the possession of paired glands, about two-thirds of an inch in length, situated half-way between the shoulder-blade and the root of the tail. As in shrews, there is a somewhat oily odoriferous secretion, and there is strong probability that this serves as a deterrent to even hungry enemies. In any case the Water Vole's ways do not suggest a timid or worried creature. The youngsters are playful and the adults can be tamed. They are not so clever as rats, but they are certainly not stupid. We have watched them off and on for long over half a century, but we never heard them make a single observation. We would rather

infer our deafness, however, than their dumbness. It is difficult to feel at all sure about their temperament. Some naturalists call them sedate and melancholy, but is there any reason to believe in melancholy *wild* animals? Water Voles are usually regarded as gentle creatures unless their sense of property is outraged. For they have a keen sense of riparian rights. Mr. H. W. Shepheard-Walwyn, in his very interesting *Spirit of the Wild*, takes the Water Vole as the expression of the spirit of contentment, and perhaps this is as near the truth as we can get just now. We would only add that they appear to be monogamous.

SHREWS

There can be no better example of elusive, self-effacing little people than the shrews. Popular prejudice against them dies hard, in spite of their elegance, nimbleness, alertness, and general winsomeness. They have been penalised by their name, by a widespread human ignorance that mixes them up with mice or field voles, and by ugly superstitions which make them scapegoats for ailments that afflict cattle and other domestic animals. Gilbert White refers to the horrible custom of making a "shrew-tree" by boring a hole with an auger in the stem, usually of an ash, putting in a living shrew, and closing the opening with a firm peg. To cure the cattle it was enough to stroke or strike the affected part with a switch cut from the shrew-tree. We suppose that this particular superstition is dead, but the prejudice against shrews lingers. The farmer no longer says, "I beshrew thee," but he still kills the shrew—certainly one of his best friends, for it destroys a great many slugs and grubs of injurious insects.

On a hedgerow bank or a dry meadow we often see a sudden movement among the herbage and dry leaves, and a little reddish-brown person darts into the open, hurries along a run, and disappears into a hole. We confess that we have never seen for ourselves the Common Shrew except in these momentary and very tantalising glimpses, but others have watched the playful gambols, the fierce combats

of the males, and the mother interlacing grass leaves to make a roof for the nest, which is hidden away among the withered leaves.

The ways of shrews are very pretty. So are the animals themselves, with their daintily small bodies, the pleasantly coloured velvety fur, and the tapering snout (shrews have the same number of teeth as we have, namely, thirty-two). Eyesight is not their strong point, but they have very keen hearing and a delicate sense of touch. They appear to be highly strung animals, and it is alleged that they often die during a thunderstorm.

The Common Shrew is represented all over the northern regions of the Old World and the New, except in islands like the Shetlands, Skye, Iona, and Ireland. It seems to be a delicate creature ; it does not store or hibernate ; its bite is trivial ; it has many enemies, such as owls and kestrels, stoats, weasels, and moles. How does the shrew hold its own ? On each of its flanks is a gland, marked by a double row of coarse hairs, which secretes a substance with a pungent odour ; and this may save the shrew from some of its more fastidious enemies. But as the repulsive secretion seems to save the shrew from being eaten, rather than from being killed, there is not much consolation here ! Then there is the puzzling habit of "feigning death," becoming suddenly inert when captured, which may occasionally make escape possible. We think also of the safety secured by the keen senses of hearing and touch—the shrew is the embodiment of alertness—and by the very nimble, unpredictably jerky movements.

Once more, there is the shrew's capacity for prolific multiplication, for there are from five to seven in a litter, and it is possible that it may breed more than once in the year. But when we add up all these factors in securing the shrew's survival, they do not seem sufficient ; and the largest part of the answer is simply, we think, to be found in the minuteness of the shrews. They are indeed a little people, and extraordinarily elusive.

The difficulty of the shrew's life is increased by its imperious appetite. Like the mole, it has very rapid digestion

and a chronic hunger. It seems to require meals every few hours, and this must be associated with the fact that while it is mainly crepuscular and nocturnal in its hunting, it also works by day. As Millais says, the Common Shrew leads the "strenuous life"; except for short intervals of sleep, it is constantly foraging, eating, or fighting, and whatever it does it does in earnest. As in the mole, another strenuous Insectivore, the hunger-urge is extraordinarily strong in the shrew, and this has probably a good deal to do with the undoubted quarrelsomeness. A hungry shrew is an angry shrew. They are playful none the less, and the mother shrew is a good mother.

One of the puzzles in the natural history of shrews is the high death-rate in autumn. Many dead bodies are found lying by the roadside and in the meadow. Various explanations have been offered. According to some naturalists, the beasts and birds of prey levy a particularly heavy toll in the autumn, and leave the victims uneaten. According to others, there is keen intra-specific competition when the territory becomes crowded and food scarce; and this suggestion is corroborated by direct observation of fighting and of wounds, and indirectly by the fact that shrews may combine on a trekking expedition when there is famine in the land. Perhaps, however, the main factor is simply that shrews are very short-lived creatures, perhaps hardly more than annuals. The seniors die off before hard times set in.

What we have said in regard to the Common Shrew applies also to its first cousin, the Pigmy Shrew, the smallest British mammal. It has a total length of only three inches from the front of the snout to the tip of the tail, and its weight is less than one-fifth of an ounce. Its skeleton is like a miniature and its thirty-two teeth are so small that they can hardly be seen without a lens. As in other Insectivores, the crowns of the back teeth are covered with "cusps"—mountain-top-like prominences well adapted for crunching small insects. The Pigmy Shrew seems to be even more widely distributed than the Common Shrew, and the more the merrier!

Deserving to be better known is the Water Shrew, which

may have a body five inches long, as contrasted with the Common Shrew's three. Technically it is known as *Crossopus fodiens*, and is widely distributed from Aberdeenshire to the Altai Mountains. As in the case of the Water Vole, it is to be regarded as a shrew that has found in aquatic life a refuge from severe persecution on land. It is a beautiful animal, velvety black above and white below. It swims prettily on the surface, half in, half out, with scarcely a ripple. Its efficiency is increased by stiff hairs on the digits, and on each side of the tail, which serves as a rudder. The food consists of insect larvæ, small crustaceans, fresh-water snails and the like, and the animal is a clever diver, often seeking its prey by turning over small stones and other objects lying on the bed of the stream. The grass-lined nest is at the end of a burrow in the bank, and the young ones are deliciously playful.

III

SOME BRITISH AND AMERICAN MAMMALS: HOW THEY HOLD THEIR OWN

WHY has Britain far fewer different kinds of mammals than Russia, or North America? The answer is interesting. Long ago (in the Pliocene) Britain was simply part of an outlying corner of the great Europe-and-Asia Continent, and it had its full share of the North European mammals, including big creatures like the Mammoth, the Woolly Rhinoceros, the Cave Lion, and the Cave Bear, all of which are long since extinct. Their bones remain here and there to tell the tale.

But the climate became much colder in the north and the Ice Ages set in, covering the country with snow-fields and great glaciers. Nowadays we can see the results of the work of these glaciers in the moulding of our hills and valleys, in the long parallel scratches (or striæ) on the hard rocks, and in the deposits of boulder-clay due to the fine mud carried by the ancient glacier-rivers. During these very severe times most of the British animals were killed off, except those that could migrate, like the birds, and those that were wise enough to trek for the south. There seems to have been a clear tract along what is now the South Coast of England, and as there was no English Channel in those days it would be open to animals to retreat towards the Mediterranean sunny lands. There were four Ice Ages, with three milder (Interglacial) periods between, and the result was practically a wiping-out of the British Fauna. During each of the milder interruptions there would be a return of sanguine animals, to the low grounds at least; but with the return of severe cold they would have to retreat again or perish. In the later Ice Ages there were *men* in North Europe, but the oldest known remains of the

" modern man type' (*Homo sapiens*) date from after the Ice (Post-glacial).

Milder climate eventually set in and the ice-sheets shrank and disappeared, leaving Britain woefully poor in living creatures. But repeopling from the Continent soon began, and a fine fauna was re-established in Britain, including such mammals as reindeer and the gigantic " Irish Elk," wild cattle and wild boars, beavers and lemmings, wolves and bears. These must have been stirring times—*the times of recolonisation*. But where are these interesting animals now? The answer is that after the recolonisation had gone so far, changes of level occurred in that part of the earth's crust, and Great Britain became an island. The same happened to Ireland, and the insulation occurred before some of the mammals that Great Britain had re-acquired had been able to reach the sister isle. Thus there is no evidence that Ireland ever had the mole or the common hare. When there was no longer any great land-bridge by which animals could enter Britain from the Continent, any further additions would be confined to flying creatures—bats, birds, and insects; and swimming animals, such as seals, porpoises, and fishes. Left without any more recruits from outside, the British mammals soon began to dwindle in number of kinds. There was competition, no doubt, among themselves; thus the wolves thinned the ranks of the reindeer, just as in the north of Canada to-day. The improvement of the climate probably went too far for the welfare of others: thus the Mountain Hare, like the Ptarmigan among birds, could only survive by keeping to considerable heights. Again, it is possible that some of the animals brought about their own destruction by going too far in some particular direction, by becoming " extremists." Thus the Giant Deer (badly called Irish Elk), whose remains are found in peat-bogs in Ireland, seems to have gone too far in its enormous growth of antlers, which must have become a burden too grievous to be borne. They sometimes had a spread of ten feet; they sometimes weighed as much as 80 lb.; and they had to be grown afresh every year by the stags.

But the chief reason for the dwindling of British mammals was Man. He hunted to procure food and clothing; and the ranks of the reindeer and the wild cattle were thinned. He hunted to secure his own safety and that of the flocks of sheep and herds of cattle he was beginning to establish, and the wolves and bears became fewer. Afterwards he hunted for "sport," but that did not do so much harm. Much more serious was the cutting down of forests in which Red Deer, Beaver, Pine Marten, and many more had found shelter. He began to cultivate, joining field to field; and that was very much against creatures that like wild and sheltered places. In scores of ways Man has been responsible for making the list of British mammals as short as it is.

Reindeer and wolves lingered in Britain till historic times, but they have long since gone; and so it is with some other fine mammals. Wild cat and pine marten were common two centuries ago, but they are now very rare; and so is it with some others. The quaint badger was once widespread, as is proved by the many place-names beginning with "Brock," which is one of the creature's aliases; but it is now confined to a few districts. The same is true of the polecat, which is either the ancestor or the first cousin of the domesticated ferret, much used in rabbiting. What we wish to do is to select *some common or fairly common* British mammals, and ask how it is that they remain when others equally well equipped have disappeared or become very rare.

SECRETS OF SUCCESS

Take the mole to begin with: How does it hold its own so well? The answer must be that it has discovered the under-world and become a burrower. It comes to the surface to find its mate or sometimes to get water to drink, but in the main it is a dweller in darkness, feeding on grubs and earthworms, and suited from snout to tail for subterranean life.

The mole requires an extraordinary quantity, for he eats about half his own weight every day. In captivity, if he is left unfed during the night, even after a good supper,

he may be found dead, with no remains of food in his stomach, in the morning. So it would not be surprising if the mole had learnt to provide against even temporary scarcity. It is said that before the beginning of winter the mole gathers great numbers of earthworms and stores them in the enlarged chamber at the end of his run, having first taken the precaution of biting off their heads, so that, though they will remain alive, they will not be energetic enough to creep away. Large clusters of torpid and wounded worms have certainly often been found in the burrows, and the mole undoubtedly eats them, but nobody has ever seen him put them there! Many naturalists believe that it is the worms themselves, often damaged, and always nearly benumbed with cold, that congregate in these convenient holes, and more observation is needed on the point. It is recorded that a captive mole would, when its hunger was for the moment satisfied, take a worm from the hand, bite it all along till it was nearly, but not quite, dead, bury it, and come back for another, which it treated in the same way. Recently, too, there have been fresh observations made which seem to show that the mole does the collecting of the worms; but even if he does it is a very temporary expedient, for the biggest cluster ever dug up—a large spadeful—would not keep a mole alive for more than two or three days!

The Common Shrew and the Pigmy Shrew, which we have already studied, how do they hold their own? The answer must be that they are very small, very alert, very quiet, very inconspicuous "little people." They are shallow burrowers, feeding on insects and many other kinds of small fry, much given to hunting in the twilight or later.

How does the Water Shrew succeed? The answer must be that it keeps *very* quiet; that it is very inconspicuous and elusive; that it can feed on a great variety of small animals, such as insect larvæ; and, most of all, that it has taken to the water. Another point, which applies to all the shrews, is that Man does not interfere with them if he thinks of what he is doing, for they check the spread of insects.



Photo · Frances Pitt.

HEDGEHOG DRINKING.

The hedgehog seems to become uncomfortable during prolonged drought and keeps itself more than usually well hidden. It enjoys its drink of water and can swim quite well with its back projecting above the surface.

The mole and the shrews belong to the order of Insect-eaters (or Insectivores), and another member of this order is the hedgehog (*Erinaceus europæus*), an old-fashioned creature, which is common over the vast area from Great Britain to the Ural Mountains. It is a biggish animal, so it cannot escape as the shrews escape—by being little. It is not a burrower like the mole, so getting underground is not its secret. Though it can swim, it is not fond of the water, so we cannot explain its survival as we explain that of the Water Shrew.

What then is the hedgehog's secret? How does it manage to survive in a country which, as we have seen, is not friendly to mammals? How does it hold its own in a land where the spread of cultivated fields (and golf-courses too) is continually reducing the number of wild places, and where wild creatures have many enemies, especially in Man himself?

Many of the hedgehog's hairs have been turned into sharp spines, which make the animal almost invulnerable. They also break its fall if it should tumble when it is climbing, as it is fond of doing. It can roll itself up into an unopenable ball, which puzzles even the crafty fox. It has a very tough constitution and is not even hurt if it gets a bite from the adder—one of its inveterate enemies. Another useful quality is that it can eat so many different kinds of animals, such as earthworms, slugs, small snails, and beetle-grubs. It does practically no harm, and to kill a hedgehog is the depth of silliness. When the cold weather sets in and animal food is scarce, the hedgehog falls into the strange state called "winter sleep" (or hibernation), "lying low and saying nuffin'," and requiring nothing to eat or drink. That is not all, for the hedgehog has made its foothold more secure by becoming nocturnal. It rests during the day in the recesses of the hedge or in the bole of a hollow tree; it hunts at night, when nobody can see it. When we hear its queer loud voice at night, we feel that the hedgehog knows that it is safe.

THE PREVALENCE OF RODENTS

When we turn from the Insect-eaters to the Gnawing Mammals (or Rodents), we find a different state of affairs—for many of them are not only common, but far too common. Rats and mice and voles are so common that people give them the ugly name of "vermin." They do a great deal of harm to all sorts of crops and stores. There were no rats in Britain before the Norman Conquest, but we may include them with the Field Vole, the Bank Vole, the House Mouse, and the Wood Mouse in our question: Why do so many gnawers become such a pest? The answer is threefold. They succeed because they multiply so quickly. They are not very strong; they are not very clever; but they are many. Secondly, they succeed because they find in fields, in stores, and in Man's careless accumulations of "crumbs" of all sorts, an unnatural abundance of food. Thirdly, they succeed beyond measure because Man has greatly reduced the number of their natural enemies, such as hawks and stoats, owls and weasels.

We need not say much about the rabbit, for the secret of its success is largely to be found, like that of the Field Voles, in the large families and in the ease with which grassy food can be procured. In spite of foxes and birds of prey, and all man's shooting and trapping, they hold their own with ease. We must add, however, that their foothold is also ensured by their burrowing habits and by their preference for feeding and playing at dusk. There is safety also in their danger-signal, made by thumping hard on the ground with the hind-feet. Even such a little detail as the bright white colour of the underside of the tail may have its value, for it serves in the twilight as a guide to the inexperienced youngsters, when the quickness of a bolt for the burrow is a matter of life and death.

How do the hares succeed? The Common Hare (*Lepus europæus*) is persecuted by the fox, and the young ones or leverets are eagerly sought for by the stoat, yet the attractive creature keeps its foothold. What are its secrets? It has very keen senses of sight, hearing, and smell; it is always

on the alert. It takes a great leap out of its resting-place when it leaves, and a great leap into it again when it returns —a simple device that breaks the scent. It criss-crosses its tracks, so that the fox is puzzled. Its fur is a garment of invisibility. The mother is very careful of the young ones, and this makes for success.

Compared with the Common Hare, the Mountain Hare or Variable Hare (*Lepus montanus*) has a stronger constitution, suited to life at high altitudes, and it is able to thrive on rougher food. When winter approaches, the Variable Hare puts on a white suit, all but the black tips of the ears.

As for the joyous squirrel, which is also a Rodent, its success depends on its having got off the ground. It has found a new world among the branches, and we might argue from its cheerfulness and playfulness that it is not much troubled about safety or bread-and-butter. In a forest it is almost like a bird in its freedom of movement from tree to tree, and it is like a bird also in making a lofty nest in which the family can be reared in safety. Even when the squirrel comes to earth to eat a palatable toadstool or bury a nut, it is still very safe, for there is always a tree-stem within jumping distance. The importance of the storing habit has perhaps been exaggerated, but there can be no doubt that the caches of acorns and beech-nuts are sometimes of use in very hard times. Even at Christmas-time one may see the squirrel jumping from one snow-laden branch to another, so it is not a winter-sleeper.

THE SECRETS OF CARNIVORES

The Carnivores or flesh-eating mammals now found wild in Britain belong to four tribes. Highest is the Cat tribe, represented only by the very rare Wild Cat, a powerful carnivore of the woods, not nearly related to the imported domestic cat. Then there is the Dog tribe, also with only one wild representative, namely, the fox. Thirdly, there are various seals, which have taken to the sea—splendid swimmers, but unable any longer to stand on their hind-legs. Lastly there is an interesting set of Carnivores that represent

the Bear tribe, not so high up in the scale as Cats and Dogs, and not so peculiar as the Seals.

The Bear tribe includes badger, otter, polecat, weasel and stoat. The example we select is the chestnut-brown stoat—a creature much persecuted by the gamekeeper, but still holding its own in spite of heavy odds. In winter it puts on white fur, all but the black tip of the tail, and in



Photo. Frances Pitt

THE COMMON MOLE (*Talpa europæa*).

The photograph brings out some of the characteristic features—the barrel-like body, the pointed snout, the absence of projective ear-trumpets the strong hand, the weaker foot, the short tail, the velvety fur without "set." Moles forage above ground at night, and they pair above ground. Much of the day is spent in exploring for food just below the surface. They are very restless creatures, of almost furious energy.

this garb it is known as the ermine. What are the secrets of the stoat?

The stoat is one of the lithest of mammals, without an ounce of spare flesh, as supple as a snake. It can disappear through what seem impossibly narrow passages. It is always in good form, quick of sight and hearing, with a keen sense of smell, always on the alert. One cannot take a

stoat by surprise, unless it is very deeply interested in its "kill." The mother takes great care of her half-dozen young ones, and she trains them well in the ways of the woods.

But the stoat's chief secret is its resourcefulness and its doggedness. One has been known to swarm up a zinc ventilating pipe that led through the roof of a greenhouse, wrench off the wire-netting at the top, slide down the pipe, kill two squirrels in a cage, suck their blood, and then climb up the pipe again—a very remarkable feat—and so off. We are almost sorry to read that when the stoat returned next day for the other squirrels it was killed by their owner, who was naturally anything but pleased at the previous day's escapade. For a short distance a rabbit can outrun a stoat, but the stoat has better wind and more endurance, and wins on a long race. The rabbit gets flurried; it is seized with a strange fear-paralysis; and the stoat is at its throat, biting the great vein in the neck.

You may stand in the way of a stoat that is landing from a swim across a river, but you will not turn it aside. If you are foolish you may perhaps brain it with a stone, but you will not baulk it. For it has not a trace of fear in its composition. A mother stoat, leading her family, will stand up to a gamekeeper and his dog. Perhaps we may say, then, that a stoat holds its own by alertness and force of character.

As we have mentioned, the chestnut-brown summer stoat becomes the snow-white winter ermine. It gets a new suit of fur; but some individual hairs may also whiten. The winter whiteness makes the ermine inconspicuous against the snow, and may help it to steal upon the grouse or escape the eagle's detection. But we believe that its chief use, as in the case of the Mountain Hare, is that it loses less of the precious internal heat of the body than would be lost if the fur were brown or any other colour. It is interesting to notice that in some places where the winters are comparatively mild, the stoat has a brown winter coat, while the stoat of the Scottish Highlands always becomes an ermine when the cold weather sets in.

THE WEASEL

As an example of a thoroughgoing carnivore we take the weasel, and there could be no better, for Britain at least, unless it be the stoat. The weasel and the stoat are near relatives and kindred spirits, but there is no reason to confuse them, as people often do. For the weasel's body is only about eight inches in length, whereas the body of a full-grown male stoat is often more than twice as much. The weasel's tail is a little over two inches long, whereas the stoat's is five or six, and ends in a black tip. Moreover, as every one knows, the nut-brown stoat of summer usually changes into the ermine of winter, snow-white, except the black end of the tail, whereas the British weasel remains brownish above. At the same time it is quite correct to say that the weasel is a small edition of the stoat, and it is generally agreed that they are two species of one genus ; in other words, first cousins. Practically, however, it is important to distinguish them, for even from the gamekeeper's point of view the reasons, such as they are, for killing stoats do not apply to weasels. For the evidence is clear that weasels feed mainly on small rodents, like field voles and wood mice, which are always apt to become dangerously abundant. No doubt weasels may levy toll on young pheasants, partridges, and other birds, and may in some cases make a habit of it, but their hunting is in the main beneficial, especially when the interests of farmers are regarded as more important than those of the game preserver. Weasels break the skulls of mice and voles; they bite larger creatures in the neck, and sometimes hang on grimly till the victim ceases to struggle.

What impresses one first about the carnivores of the weasel-stoat-polecat-marten tribe is their consummate fitness. The weasel's body is spare and lithe, perfectly adapted for exploring a burrow or for disappearing among the stones of a dry dyke. There is a suggestion of the snake in its sinuousness. The creature swims and climbs as effectively as it runs and leaps. For one must distinguish a rapid progression, with the body low and straight, from an

even quicker succession of leaps and bounds. There is no flabbiness in the weasel and hardly any fat in its body. The colour of the upper fur harmonises with the soil and the withered herbage. The teeth are small but extremely sharp, and, for an eight-inch animal, the weasel can give a very shrewd bite. The senses of sight, hearing, smell, and touch are unsurpassed, and we suppose it is almost impossible to catch a weasel napping. They seem to be always on the *qui vive*, but this is not inconsistent with a considerable degree of preoccupation when they are playing or in hard pursuit of their prey. Intent is a word that describes them. It must be remembered that a good deal of their hunting is done at night, and Millais refers to the belief in certain parts of the country that hares are sometimes pursued in the darkness by packs of fairy hounds, the "Dandy Dogs." These are doubtless weasels, which often hunt in small companies—perhaps family parties. As in related animals, there is an education of the young ones by the parents or by the mother alone, and this may be the true interpretation of the hunting in small packs. At heart the weasel is an individualist, that is to say, he prefers to be "on his own."

An impressive quality is the weasel's fearlessness. It is not the fearlessness of a penguin or a sea-cow, which is rather stupid and ignorant, but the fearlessness of wide-awake defiance. A weasel will tackle an animal many times its own size—a rabbit, for instance ; it will face up to a dog ; small packs have been known to attack man. This courage is, of course, most marked in a mother leading her family, but it is a quality of all weasels. It grades into an extraordinary pertinacity, an indomitable resourcefulness, of which there are many well-authenticated instances. Thus it is certain that when a starving bird of prey has gripped a weasel in its talons and flown away with it, the victory may be in the long run with the captive, who manages to give a fatal bite in mid-air. There is a wonderful doggedness about a weasel, but it is associated with presence of mind and courageous cleverness. "Never say die" is its motto, and the reward of the ages has been that the weasel has very few natural enemies. We are often impressed with the rewards

that come to those creatures that practise self-subordination and mutual aid, but there is success also along the other evolutionary tack of self-assertive audacity. The weasel is " a braw fighter "—a gentleman unafraid.

The other aspect is well seen in the weasel's maternal care, for there is long nurture and careful education. In May or June the four to six young ones are born in a cradle among stones or in a tree-stump. They are for a long time blind and helpless, and the mother has her hands full. If danger threatens she shifts them to another shelter, carrying one at a time in her mouth, as a cat her kitten. Even when the young one is able to move about a little, the mother will seize it at a critical moment and carry it quickly into safety. There must be prodigious strength in the muscles of the jaws and neck, for we have seen a weasel dragging a biggish rabbit off the roadside into a thicket, and the clean lifting of the young one, and carrying it for a considerable distance at a smart pace, is a wonderful gymnastic feat. In addition to the maternal nurture and carefulness there is a genuine education. The mother trains her young ones in the ways of the wild, and in a delightful playfulness they serve an apprenticeship to the responsible business of their life.

There are some striking features in the behaviour of weasels. One of these is the " blood fury " they sometimes exhibit when opportunity offers for destruction on a large scale. Among chickens, for instance, they will kill right and left, victim after victim, far beyond all possibilities of immediate need. It is true that weasels sometimes bury their " kill," showing the first hints of a storing habit ; but the meaning of the " blood-fury " is probably that an uncontrollable killing instinct is aroused, and kept aroused, by the sight of an unusual and sometimes unnatural abundance of booty. We have already spoken of the occasional intensity of preoccupation. When two weasels are having a thoroughgoing quarrel they sometimes seem careless of interference. The same is true, though the limit is more quickly reached, when the preoccupation is with a game or with display before birds. Perhaps the apparent recklessness points to a relatively limited intelligence of the " one-thing-at-a-time "

order; but perhaps the explanation is to be found in the safety which the weasel has won for itself in the competitive struggle for existence. Another peculiarity, also well marked in stoats, is the occasional trekking or raiding in companies. Sometimes it is a family journey in which the mother leads her four or five kittens; sometimes there is a troop of twenty or more on the march in search of a new country. On such occasions it is profitable for both man and dog to exhibit discretion rather than valour. When a hard winter sets in and the ground is white the weasel makes tunnels beneath the snow, and its keen sense of smell often leads it to the hiding-places of mice and voles. In North Europe, though not in Britain, the weasel often changes into a white dress in winter. The so-called "white weasels" of Britain are very pale colour varieties or true albinos, not illustrations of seasonal change.

As to the badger and the otter, they cannot be called common except in a few parts of Britain, and we have already referred to them, as also to Reynard the Fox.

As to seals, which are sometimes to be seen in scores on the West Coast of Scotland, the main secret of their survival is that they have become so thoroughly aquatic. Their ancestors left the crowded land and took to the friendlier sea, where seals are now at home. The dangerous time in the seal's life is when the mothers have to come on to the shore rocks to give birth to the young ones, and when these young ones are lying helpless, unable even to swim if they tumble into the water. Many animals that have changed their habitat go back to the old home to start another generation.

STRANGE SUCCESSES

Belonging to a very different order from the seals are the porpoises and dolphins, which are often to be seen playing in the sea off British coasts. They belong to the order of whales or Cetaceans, and they show in various ways that they have been aquatic for a much longer time than the seals. Thus there is no external trace of the hind limbs, and there are only traces of hairs. Porpoises and other

Cetaceans have this great advantage over seals, that the mother can bring forth her young one in the water and suckle it there. This means that the ancestors of porpoises must have left the dry land long before the ancestors of seals got that idea into their heads. Thus porpoises and their relatives greatly excel seals in their fitness for aquatic life.

Of all the British mammals the strangest are the bats, to which we have already referred. They have four chief secrets. First of all they can fly. They have found a new kingdom into which no other mammals can intrude ; and they are almost as well suited for aerial life as birds. Secondly, they are nocturnal, hiding during the day and coming out at dusk to hawk insects, sometimes high in the air, sometimes so near the ground that they almost brush our face. But they have a marvellous sensitiveness that keeps them from knocking against anything. Thirdly, bats fall into a " winter-sleep " when the cold weather comes. It is a true hibernation, but it is not so deep as the hedgehog's, for bats awaken if there is a spell of mild weather—even at Christmas-time. In cold places the bats remain " asleep " all through the winter, clustering together on the rafters of a barn, or in the sheltered nooks of an old tower, or inside the hollow trunk of a decaying tree. Strange creatures that hang themselves up by their toes, and wrap themselves up in their arms ! Fourthly, the mother-bat takes great care of her baby—and that always makes for success.

SOME NORTH AMERICAN MAMMALS

The mammals of North America (Nearctic) have a general resemblance to those of the north of Europe and Asia (Palæarctic), and the two great regions, considered from the point of view of geographical distribution, are often united under the title Holarctic. In the northern parts of both the Old World and the New, we find such types as tailless hare, marmot, pouched-marmot, beaver, lemming, field mouse (but no Mus in America), sheep, bison, reindeer, elk, polar bear, glutton, and lynx. But mole, water-vole, badger, camel, yak, chamois, and dormouse may be

mentioned as characteristic of the Old World, just as pouched rat, musk-ox, prong-horn, Rocky Mountain goat, prairie-dog, musk-rat, skunk, and raccoon are characteristic of the New. It may be interesting, therefore, to pick out a few North American mammals and ask how they manage to hold their own. Unfortunately, just as in Britain, it has to be admitted at once that many of them are *not* succeeding. In spite of vigorous protective measures and the wise enthusiasm of men like Dr. W. T. Hornaday, of the New York Zoological Park, there is a sad diminution of such interesting mammals as the unique Prong-Horn Antelope, the Big-Horn Sheep of the Rockies, the Mountain Goat, the Wapiti, the Caribou, the Moose, the Musk-Ox, and even the Grizzly Bear. (See Hornaday's *Our Vanishing Wild Life.*) It is to be hoped that greater appreciation of these irreplaceable treasures will save them from extermination.

In the interior of North America, on the great treeless plains, one of the most characteristic sights is a " town " of prairie-dogs. As the train rushes through on a transcontinental railroad, the traveller may see in suitable places hundreds of plump, somewhat squirrel-like rodents (*Cynomys*), considerably over a foot in length, sitting bolt upright by the mounds which mark the mouths of their burrows. We read that " in the entire state of Texas 90,000 square miles are occupied by prairie-dogs, and the number of these animals within this area runs to hundreds of millions." They are legion ; how do they get on so well ?

The first part of the answer is that these gnawing mammals find an abundant food-supply in the stems and roots of prairie-grasses and other plants that flourish in these vast expanses. For relish they will eat grasshoppers and the fruits of the pear-leaved cactus, but in the main they are voracious vegetarians, levying heavy toll on the crops that encroach on their wildernesses. No doubt as agriculture advances, the prairie-dogs must yield ; but while they may disappear locally, they are, as a species, safe for centuries. This is the more certain since, like most other rodents, they are very prolific, working with a big margin.



Photo: F. W. Bond.

THE PRAIRIE-"DOG" OR MARMOT (*Cynomys ludovicianus*).

The prairie-"dog" of North America is fourteen to seventeen inches in length. It is first cousin of the ground-squirrels, and has short ears, limbs and tail. It is a voracious vegetarian, feeding on the stems and roots of prairie-grasses, and is quite independent of water except in so far as it is able to extract it from its food; thus it thrives in the driest places.

But what is there besides the abundant food-supplies and the prolific reproduction? Being numerous and palatable they are obviously of value to coyotes and foxes, eagles and owls, yet this is in some measure met and baulked by a high development of social vigilance. When an intruder is detected, a prairie-dog makes for the nearest mound and sitting bolt upright "barks" for all he is worth. Hence, we suppose, the name of "dog," but he also wags his tail. In a very short time, as Mr. Nelson says, "the 'town' is alive with scurrying figures of the inhabitants rushing panic-stricken for their homes, and the air is filled with a chorus of their little barking cries. When all have been frightened to cover, barking continues in the burrows, but an hour or more may pass before a 'dog' will reappear." (See *Wild Animals of North America*, National Geographic Society, Washington, 1918.) The mothers are said to teach their offspring to obey the danger-signal with promptness, and there is great native alertness to start with. Prairie-dogs are very much on the spot, and, as we have said, they will hold their own—even in spite of their dangerous quality of being edible. They have two other advantages, that they can thrive without water, except what they extract from their food; and that they can hibernate for months in severe weather or in exposed haunts. There is no warrant, of course, for the picture of their "happy family" along with owls and rattlesnakes. "The truth is that the owls live and breed in deserted dog holes, while the rattlesnakes visit the occupied holes to feed on the unfortunate occupants." The prairie-dogs are interesting enough without this brightly coloured legend. As Topsell said in his *Apologia* (1607): "Truth on every part is so deare unto me, that I will not lie to bring any man in love and admiration with God and his works, for God needeth not the lies of men."

Balancing the Ground Porcupines of the Old World are the Tree Porcupines of the New. They are very markedly contrasted with the prairie-dogs, but they belong to the same order of Rodents or Gnawing Mammals. The name "hedgehog" that they sometimes get is a very bad one,

for the hedgehogs belong to the order of Insectivores. Best known, and yet not very well known, among the tree porcupines is the "Canadian" species, (*Erethizon dorsatus*), found from Hudson Bay to Ohio—one of the quaintest of mammals, about twenty times as large as a European hedgehog. It is a black creature, "with a grey-tipped storm-coat"; it is slow-going and slow in the uptake, it has not good sight, and it lives as a solitary. How does it hold its own? Part of the answer is to be found in its use of many kinds of rough vegetable food, such as bark, in its preference for the darkness, and in its arboreal habits. It may stay for weeks on the top of one tree, gnawing at the bark, but it usually has a den on the ground, and it may wander far in search of luxuries like fruit and salt. The young ones are born very large and well-equipped, soon able to fend for themselves, and in this also there must be safety. But when we add up all these qualities, we have not yet explained the tree porcupine's survival, for it has many enemies among predatory birds and beasts with quicker wits. The porcupine is saved by its spines!

These sharp defences are transmogrified white hairs of the under-fur, and are overlaid by the coarse black and grey outer hairs. They lie flat when the creature is quiet; they bristle when it is excited; and they have such a loose attachment to the skin that they break off when the point enters the skin of the assailant. The porcupine has a very effective way of swishing its short, club-shaped, spiny tail on the enemy, whose skin is thus pierced by many darts, which may be fatal and are almost certain to be tormenting. But in spite of many asseverations to the contrary the tree porcupine cannot shoot its spines. The same negative holds for the Old World Porcupine (*Hystrix*).

It rattles its long spines in raising them; it charges backwards and sideways with them all bristling; and it often loses them, for are they not transformed hairs? But shoot them it cannot. Not even Buffon believed this, for he said on this very subject: "The marvellous is pleasingly believed, and increases in proportion to the number of hands it passes through." The quills of the Old World Porcupine

may be over a foot long, those of the Tree Porcupine vary from half an inch to rather over three inches in length. But they are long enough to have " survival value " !

The Rocky Mountain Goat (*Oreamnos montanus*) is a big-game mammal of North America that holds its own with considerable success. What is its secret ? It is a creature of the cliffs, very sure-footed, able to thrive on scanty vegetation, well-protected from the cold of winter by its coat of shaggy white hair. It has a long heavy head bearing small black horns ; it is humped at the shoulders like a buffalo ; it is enormously strong. It ranges from Alaska easterly and southerly through the mountains to Montana and Washington, and it seems to have few natural enemies. It seems to be a slow-going, not very adventurous creature, believing a good deal in " Safety first." Mr. E. W. Nelson writes of these American wild goats : " They are reputed to show at times a stupid obstinacy when encountered on a narrow ledge, even to the point of disputing the right of way with the hunter." Every game animal is liable to have its range restricted by man's overshooting, but the persistence of the Rocky Mountain Goat is assured by its liking for inaccessible retreats. Dr. Hornaday praises its coolness in finding an unassailable position and waiting there undismayed. " Mentally the Mountain Goat has the steadiest nerves, the most indomitable courage, and the greatest coolness in the face of danger that I am aware of in any hoofed and horned mammal." Fortunately, the flesh is too musky and dry to be palatable ; the skin is of no commercial value ; and the head is not much of a trophy. So the Mountain Goat will live on for many a day.

One of the most unpopular of mammals is the Common American Skunk (*Mephitis mephitis*), widely distributed from the Atlantic to the Pacific, from Hudson Bay to Guatemala, common in woodland and thicket, and with a very firm foothold in the struggle for existence. What are the secrets of the skunk ? As a member of the Mustelid family, beside the stoat and the weasel, the mink and the marten, it is of course highly endowed as regards muscle, brain, and sense-organs. Like many of their relatives,



Photo: F. W. Bond.

COMMON CANADIAN SKUNK (*Mephitis mephitis*).

This species of skunk is common in the woodlands of the northern United States. Its fur, which is in great demand, is jet-black in colour, with two broad white bands down the back. Although the skunk is an enemy of the poultry-yard, it does great service in destroying injurious insects not to speak of mice, wood-rats and other small rodents.

skunks have a long bill-of-fare, from grasshoppers to rats, from wasps to frogs, from fish to ground-nesting birds. While they levy toll on game-birds, they pay man back by checking injurious insects. Another reason for the survival of skunks is to be found in the care that the mother takes of her young ones. There are half a dozen or so in the comfortable nest that is made in the recess of the burrow or den, and the mother gives them not only food but educa-

tion, just as in the case of the otter. When she is teaching them the ways of the woods, they often follow her in a long Indian file. Here we have undoubtedly a kind of matriarchal family life, and it may be kept up for about a year. Another life-saving quality of skunks is that, on the whole, they prefer night to day. But on none of these qualities does the skunk's safety mainly depend. Every one knows that they owe most of their safety to the intolerable smell of the secretion that they squirt out from two glands situated near the end of the food-canal. The animals are conspicuous by day in their jet-black fur with two white stripes along the dorsal surface, but they move about with deliberation and confidence. "Long experience has taught them that the right of way is theirs." If other creatures dispute it and will not take a hint, the skunks squirt out the nauseous secretion, and the double jet can carry for two or three feet. It must not be supposed, however, that this defence brings them more than partial safety, for many fall victim to the appetite of predatory birds and beasts, such as coyote and puma, harpy eagle and great horned owl. Moreover, the flesh is palatable and the fur is increasingly in demand. Sometimes, indeed, men start skunk farms, where the animals are bred. In these cases the scent-sacs are removed by a simple surgical operation. It may be noted that skunks are rather gentle creatures, by no means averse to man's company and protection; the young ones are playful and affectionate.

Besides the Common Skunk, there is the Hog-nosed Skunk (*Conepatus*), with a single white stripe along the back. It has its headquarters in South America, but overlaps the commoner type in its range. It is more of a burrower, more nocturnal, and more insectivorous.

Another relative is the small North American Spotted Skunk (*Spilogale*), "distinguished from all other mammals by the curious and pleasing symmetry of the black and white markings." It is very varied in its diet, including even fruits and mushrooms; and it is very unlike the other two kinds in its agile movements. As usual, the Spotted Skunks squirt out a double spray of nauseous fluid. It was of them that Hernandez wrote in 1628: "The powerful

arm which they use when in peril is the insupportable gas they throw out behind which condenses the surrounding atmosphere so that, as one grave missionary says, it appears as though one could feel it." Many carnivores have these scent-glands with a repulsively malodorous secretion, but we get a glimpse of one of the ways of Organic Evolution when we consider the case of skunks, where this feature has been exaggerated into a life-saving habit.

Widespread in North America are the exquisite Flying Squirrels (*Glaucomys* or *Sciuropterus volans*), which show a life-saving feature without a parallel in Britain, namely, a parachute. This consists of a delicate extension of the skin between the fore and hind limbs, and it enables the dainty creatures to volplane from tree to tree in the dusk. They can control their movements in the air, and ascend at the end of a descent, but there is no real " Flying," such as bats show. In other words, the sheet of skin does not actively strike the air.

The American Flying Squirrels are engaging little creatures, about five inches long and four more to the tail; they live in holes in trees, sometimes gregariously. They are nocturnal, as their large eyes suggest, and they are sometimes seen playing joyously at dusk. During the day they lie sleeping, rolled up in a furry ball. They are able to thrive on very diverse food, acorns and birds' eggs, beech-nuts and insects; buds and corn; and this of course helps them to hold their own. Another quality that makes for success, as we have already emphasised, is the strong maternal care. Mr. E. W. Nelson tells of a case where the helpless young were removed from a nest in a hollow stub and placed on the ground at its base. " The mother soon returned and not finding her family in the nest, promptly located them on the ground. Quickly descending, she took one in her mouth, carried it to the top of the stub, and, launching into the air, sailed to a tree thirty feet away, up which she carried her baby and placed it safely in a knot-hole. The trip was quickly repeated until the family was reunited in its new location." One feels that the Flying Squirrel has a right to survive!

These instances must serve to illustrate the variety of ways in which American mammals hold their own, but the subject is endless. Everywhere we see creatures utilising some device, some niche of opportunity, some new departure or other in structure or in habit, which strengthens their foothold in the struggle for existence and the endeavour after well-being. The opossum feigns death and is often successful in making its escape ; the gophers or pocket-rats live as miners beneath the ground ; many of the squirrels have found safety in the tree-tops. The minks among carnivores and the musk-rats have taken to the water where they hunt respectively for fish and water-plants. Many American mammals have sought and found safety in darkness ; a few are camouflaged ; others have made a strength out of a weakness by falling into winter-sleep ; a few have proved in their sociality that union is strength. But the problem to which these are answers is always the same. The problem is to keep body and soul together. "Why do the people strive and cry ? " the poet asked, and the answer came : "They will have food and they will have children, and bring these up as well as they can." This is true of "people" ; it is also profoundly true of animals.

IV

MAMMALS OF THE NORTH

THE land surrounding the Arctic Ocean supports only a few kinds of mammals, and these, with two exceptions, are but small in size. Yet the Polar basin itself is the home of a many very large mammals, some of them the largest animals now in existence. What is the reason for this difference ? It lies in the fact that the sea is very rich in microscopic organisms, both plant and animal, and on these minute forms of life all the others ultimately depend. The dependence may not be direct, but it is none the less real, however many be the links in the nutritive chain.

Thus—to take a long chain—the Polar Bear feeds mainly on seals but the seals feed on fishes ; the fishes depend on the exceedingly abundant crustaceans, and these again find their food supply in the millions of microscopic plants and animals that people the surface of the ocean. The first link in the nutritive chains of the sea must always be found in the microscopic plants like diatoms; for all green plants, whatever be their size, have the power to live on inorganic material—air, water, and salts. With the exception of a few minute animals that have gained possession of the characteristic green pigment of plants, chlorophyll, no animals can feed as plants do, and thus the inexhaustible supply of nourishment to be found in the inorganic world has first to be made available by the plants.

In some places there are abundant seaweeds, and these afford pasturage for many animals such as sea-urchins ; while the débris or plant-dust sinks downwards and outwards to enrich the mud on the floor of the sea. Another point of importance is that the icebergs, breaking off from the sea-end of the glaciers, often carry much rock-waste, which

adds to the depth of the mud. In the summer there are similar contributions of great magnitude from the turbid glacier rivers. What forms fertile alluvium on an inland plain—at the foot of the Alps, let us say—becomes in Arctic regions the soil of the sea.

The question rises why there should be such prodigal abundance of minute organisms in the surface waters of northern regions, for they are far more plentiful there than at the Equator. The late Sir John Murray used to say that no one with a boat and a tow-net need starve in northern waters, for in a short time it is easy to catch a substantial meal of small crustaceans. These little creatures, distantly related to shrimps, are highly nutritious, for their bodies contain a considerable proportion of oil, which is very useful as part of man's diet in cold surroundings. In addition to small crustaceans the cold waters contain abundant free-swimming molluscs, *e.g.* the "sea-butterflies" that form a great part of the food of baleen whales. There are many other minute swimmers and drifters of great practical importance to man, because they have made the northern fisheries so successful, but the fundamental fact is the inconceivable, though not incalculable, numbers of minute green plants that form the "floating sea-meadows." With these plants we must include microscopic green animals like the Peridinids which are able to feed at the same low level as plants do.

A further question arises. Why should the number of individuals of a given species, of diatom or peridinid, be greater in the colder than in the warmer waters? The probable answer is that the low temperature slows down the vital processes so that the tenure of life is longer, and thus there are more generations living at the same time than in warmer waters, where the rate of vital change or metabolism is greater, and the length of life shorter. In any case the fact is that, while there are more kinds of peridinids, for instance, in the southern waters, the number of individuals is far greater in the north.

THE POLAR BEAR

The Polar Bear is a magnificent instance of life's conquest of the cold. It dares the worst, for it seldom comes beyond the southern limits of the ice-pack. Most of its summer is spent on the circumpolar ice, or swimming tirelessly in the open spaces; in the dark winter there has to be a continual exploration of islands and continental coasts in search of food. It is only at this hungry time that the Polar Bear is distinctly aggressive towards man.

Not only is the Polar Bear the largest of its tribe—attaining to nine feet in length—but it is the most thoroughly carnivorous. It must require a large quantity of animal food, and yet its home is the frozen polar sea.

The explanation as indicated is the abundance of seals. Animate nature implies cycles of incarnations. The Polar Bear seems to find the seals rather by scent than by sight, and it is very clever at taking them unawares. In one case a bear swam across a patch of open water to a seal basking on the ice, and, raising itself half out, crushed the seal's skull with one stroke of its paw.

Even more striking is the feat, well vouched for, of lifting a seal clean out of the water with one stroke. The bear was seen lying on its belly at the edge of a floe waiting patiently for a seal to come to the surface to breathe. "No sooner had the seal's head appeared than one fell stroke of the heavy paw of the bear landed its prey, stunned, on to the floe." In this case there was not only a feat of strength; there was good judgment, enduring patience, and great rapidity of action at the critical moment. The Polar Bear is an expert stalker.

The Polar Bear can swim for many miles without apparent fatigue; its thick coat and its fat must help to conserve the precious animal heat; the quite unusual hairiness of the soles of its feet may perhaps make the footing on the ice more secure. The whole animal spells success.

Scottish whalers used to call the Polar Bear the "Brownie," in reference to the creamy-yellow colour of the fur, which is often very like the "yellow ice" that occurs in patches

all over the floe. The yellowness is due to an admixture of microscopic diatoms among the ice. The late Dr. W. S. Bruce, who had great experience in Polar exploration, points out that while the bear's yellowness makes it almost conspicuous in its natural surroundings of white ice, it provides a cloak of invisibility among the yellow patches. He tells of a Polar Bear that approached within a hundred yards of a congregation of twenty-five sailors who were having a service on deck, and was unseen by all but the mate, who was reading the lessons. The bear was in full view, yet almost invisible, it was so like the yellow ice !

As the Polar Bear has practically no enemies except man, we cannot suppose that its yellow colour has a utilitarian significance in saving it from molestation. Nor can we place much confidence in the theory that the colour has its *raison d'être* in the help it gives the bear to keep itself hidden whilst stalking. For the yellowish colour is rather conspicuous against the white ice, as the word " Brownie " suggests. The utilitarian interpretation, if it is wanted, must be sought elsewhere, namely, in the fact that, for a warm-blooded animal in very cold surroundings the physiologically best dress is white fur, for it loses least of the precious animal heat. Next to snow-white comes creamy yellow. The Polar Bear is whitest when young, and it is whiter at the end of winter and in early spring than at other times of the year.

A curious fact is the appearance of a white band on the dorsal part of the neck of a newly-born brown bear, like a similar, but persistent collar on the under part of the neck in the Asiatic Sun-bears and Collared Bears. Since characters that are present in youth and afterwards disappear are usually regarded as indicative of ancestry, one cannot but ask whether the newly-born Brown Bear's white neck-band may not be a hint that the ancestral bears were light in colour.

The error of calling the Polar Bear a winter sleeper dies hard. There is no true hibernation in the Polar regions ; it is prohibited by the intense cold, both above ground and under ground during the long months of darkness. All that happens in the bear's case is that it may make a sort of

cave of snow and ice in very severe weather, or at the time when the female is about to give birth. This takes place in winter, and there is of course much need for temporary shelter both for the mother and the one or two naked cubs. But they do not stay long in their den among the snow-hummocks, naturally enough, since food has to be found, and that means tramping about.

The Polar Bear is a devoted mother and she will defend her young ones with complete disregard for her own safety. The two or three bears sometimes seen together mean a mother and one or two cubs; and the apron-strings are cut when the time of apprenticeship is over. Except at the pairing-time the males and females live apart—stern individualists.

Let us then salute the Ice-Bear, for that is its truest name—a supreme Polar explorer, a conqueror of the cold, strong as a lion, callous as a yak, a better stalker than any cat, more patient than any dog, severely individualist and yet motherly; inexterminable, let us hope, in its Polar fastness. Vivat Ursus maritimus!

THE WALRUS

Next to the Polar Bear as characteristic of the Arctic Seas must be ranked the walrus (*Trichechus rosmarus*), that quaintest of circumpolar mammals. The walrus belongs to the same family as the seals, but it is larger than any of these. It is usual to distinguish two forms, a Greenland and a Pacific, but the differences between them are mainly a matter of size and weight.

"Of all living monsters that ever move upon land," writes Dr. Hornaday, of the New York Zoological Park, "the Pacific Walrus is one of the most wonderful. A full-grown male is a living mountain of heaving flesh, wrinkled, furrowed and seamed, ugly as a satyr, and as strange in habits as in appearance."

Not a very attractive animal from this description! The walrus has its good points, nevertheless, even in appearance. The head, with its heavy moustache, is relatively small, and the shoulders are very broad and massive, so that

when a herd of walruses is seen from in front in their favourite position, almost erect in the water, they are described as looking nothing less than majestic. They have sometimes been credited with being the originals of the mermaid legend, but that distinction is now generally accorded to the sea-cow.

A full-grown male walrus is about twelve feet in length,

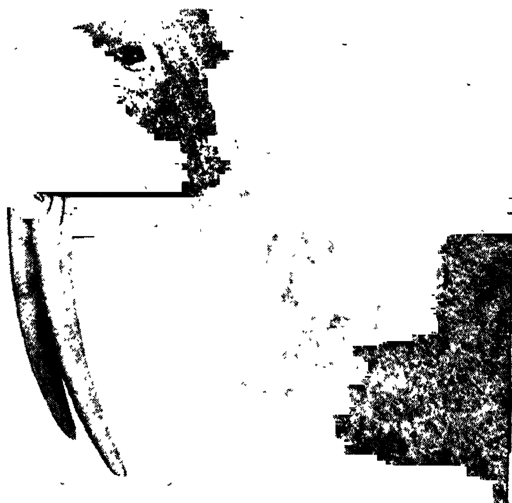


Photo: W. S. Berridge, F Z S.

HEAD OF ADULT WALRUS

The tusks of the walrus are exaggerated canine teeth of the upper jaw, which may be thirty inches in length. They are perhaps of use in digging up molluscs from the sea bottom, but they probably illustrate what may be called "momentum in evolution."

and weighs between 2000 and 3000 pounds. The skin is very thick, rough, and warty. The young walrus has a covering of short brown hairs, but as it grows the hairs tend to fall out, and an adult may be nearly if not quite naked. The muzzle is mobile, and bears long, very thick bristles, which, from their arrangement about the mouth, are believed to act as a sieve.

The upper jaw bears two long canine teeth or tusks, those of the female being slightly longer though not stouter than in the male. The tusks go on growing throughout life, and may reach a length of three feet. They have several uses and are of very great importance to the life of their possessor. They are formidable weapons, for the walrus can strike downwards, sideways, and even upwards quickly and effectively. Even the Polar Bear, which is the only animal strong enough to attack him, has to be very wary, for if the walrus succeeds in pinning him down he will hold him under water until he is drowned. The tusks are also used, it is said, in clambering up the slippery side of the ice-pack.

But their chief use is in food-getting. The walrus feeds mainly on the clams and other molluscs that abound in the mud of the shallow waters, and these mud-animals he digs up with the points of his tusks. He can remain under water for a long time—even up to an hour, it is said, though that must be very unusual—and the great weight of his bones, which are heavy relatively to his enormous bulk, helps him to keep his balance on the floor of the sea. It used to be thought that molluscs, with crabs and smaller crustaceans, formed his sole food, but investigation of the contents of the stomach has shown that many fishes, and even an occasional seal may be consumed. Thus, it is probable that the Walrus, like the Polar Bear, takes whatever animal food it can get at the moment.

The feet are webbed. The fore-foot bears small nails, and underneath it has a rough pad which helps the walrus to keep its footing on slippery ice. The fore-legs are free from the elbow, but the hind-legs are enveloped nearly to the foot by a fold of skin, which also encloses the tail. Obviously then, the movements of the walrus on land must be difficult and clumsy. Yet he does not flop along like his seal-cousins, for he has an advantage over them in being able to turn his hind-feet forward, so that he can walk after a fashion. But the sea is his real home and he rarely goes far from the water s edge.

It is not because of any peculiarity of its own constitution that the walrus is confined to the Arctic seas ; it has simply

been driven farther and farther north by constant persecution. As late as the fifteenth century its wanderings extended to the north of Scotland, and much later than that it was common in Iceland. Now it is comparatively seldom seen even on the northern coasts of Spitsbergen, where, we read, in 1852 a hunting expedition destroyed so many hundreds in a few hours that the ships were quite unable to carry more than half of them away, and the bodies of the rest were left to rot slowly on the beach. Nowadays the Atlantic walrus remains all the year round among the ice to the north of Greenland, while the Pacific form occurs all along the coasts of Alaska and moves freely about among the islands of the Behring sea. In these remote regions they are fortunately still abundant. An American observer reports having cruised for hours along the edge of the ice-pack on the shores of Alaska, all the time passing " an unbroken line of walruses, which must have numbered tens of thousands."

When resting on land, they always lie very close together, and this habit must help to keep them warm ! But the preservation of the animal heat depends also on the thick layer of fat they put on in summer when they are active and their oily food is abundant. Like other warm-blooded animals they can call on their muscles to produce more heat when it is wanted. In autumn they become lethargic and often lie in heaps for days at a time without going to look for food. They do not set sentinels as do many gregarious mammals, but they have a method of watching all their own ! One walrus wakes up suddenly, looks all round suspiciously for a minute or two, then gives his next neighbour a push, and composes himself to sleep again. The neighbour does the same, and prods the walrus on the other side, and so on all down the line. Since the line may include hundreds of individuals they can obviously never all be asleep at the same time.

For the two or three months of the breeding season the walruses remain on land, or as close to it as their feeding-grounds will allow. They are not polygamous like the seals, but live in pairs. Only one young one is born at a time, at

any rate in the Pacific form. Indeed, it is difficult to see how a walrus mother could ever look after more than one such huge baby, for she keeps it with her and even suckles it till its second year. The reason for this very prolonged nursing seems to be that the tusks are slower in developing than the body, and till they have grown the youngster has no means of digging up its own food. The mother walrus is very devoted to her offspring, and, timid at other times, she becomes fierce if danger threatens it. She dives into the water holding her young one between the forelegs, but in the water she carries it on her back. Dr. Bruce reports having seen a herd of over a hundred mothers swimming near the ship, each with her baby on her back. Young walruses have sometimes been taken captive, and have shown themselves sociable and playful, but they always die soon, and adults can never be kept alive in captivity.

The walrus is of the highest importance to the coastal tribes of Eskimos. Seal meat and fat may be more palatable, and sealskins make softer garments, but walrus "veal" is not to be despised, and even the beef can be made to serve when other things fail. The thick skin makes admirable harness for the sledge dogs; the blubber is used for lighting and cooking; and the ivory of the tusks, though neither so hard nor so white as elephant ivory, is made into drinking vessels. The bones and sinews, too, are put to many uses.

The Eskimos kill the walrus easily enough on land, and hunt it in their light skin-covered canoes at sea. That is a hazardous enterprise, for though walruses are not naturally combative they throng about the boats from curiosity, and the killing of some incites the others to rage, and they will attack a canoe and overturn it with a single blow. Against the Eskimos with their canoes and harpoons the walrus could hold its own, and the number needed for food would make little impression on the vast total. But unfortunately the blubber, hide, and ivory are of value to many besides Eskimos, and it was the ruthless and wasteful killing by the earlier traders that brought this interesting animal so near the verge of extinction, except in the least accessible parts of the Arctic seas.

OTHER MAMMALS OF ARCTIC SEAS

There are many seals in the Arctic Ocean and they have gone even further than the walrus in the way of becoming aquatic, for their hind-legs are turned backwards and connected with the short tail to form a powerful propeller. Seals are thus at a great disadvantage when on land, and their awkwardness of movement is apt to be their undoing. Their way of life has already been discussed.

As there are many seals, so there are many whales of different kinds. Absolutely confined to the Arctic Ocean, but dwindling rapidly in numbers, is the huge Greenland whale, from fifty to seventy feet in length, which feeds delicately on the teeming multitudes of pelagic crustaceans and molluscs, caught and strained off on the frayed edges of the baleen-plates, and then collected on the tongue. Very striking is the white whale or beluga, with a cream-coloured skin, a cetacean about ten feet long that skirts the Arctic shores, and ascends the rivers in pursuit of salmon and other fishes. A very interesting point is that the young belugas are blackish, and only become white as they grow up.

Related to the white whale is the sailor's "unicorn," the narwhal, which is also circumpolar. It is famous because of the reduction of the teeth to one—the long, spirally twisted tusk of the male, in rare cases double. It is rudimentary in the female; it may be seven or eight feet long in the male! But the use of it seems very uncertain.

One more mammal of the Arctic seas we must mention—the Sea Otter (*Enhydris lutris*). It is the only member of the otter tribe that is really marine, though our common otter, to which it is distantly related, often frequents estuaries and river mouths. The sea-otter is now rarely seen, although in the glorious days—for the sea-beasts!—before commercial enterprise and firearms had penetrated to the Far North, it appears to have been very abundant. Its movements on land are clumsy, but it is a powerful swimmer; and herds have been seen as far as fifteen miles from land. They are very fond of floating on their backs with the hind-legs and large webbed feet stretched out,



Photo: Herbert G. Ponting, F.R.G.S.

WEDDELL SEAL (*Leptonychotes weddelli*).

This powerful southern seal is found on or near all Antarctic shores. It feeds on true fishes, cuttlefish, and other molluscs, then comes ashore and sleeps heavily while digesting. A favourite position is turned almost on its back.

and they resume this position at once after fishing. We are told that a sea-otter will amuse itself lying thus by throwing a ball of tangle from one "hand" to the other, and a mother otter, holding her baby between her fore-arms, "would play with it for hours at a time."

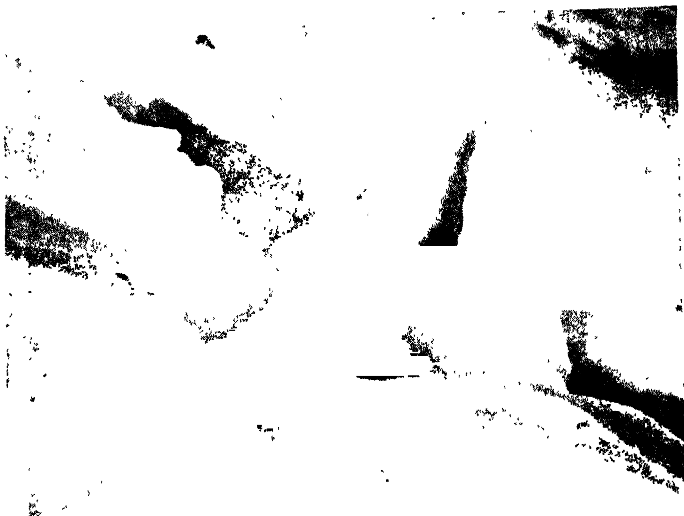


Photo: Herbert G. Ponting, F.R.G.S.

WEDDELL SEAL COMING UP TO BREATHE.

The Weddell Seal feeds to a considerable extent on what it can secure off the bottom in comparatively shallow water near shore, and it has to come up at frequent intervals to get a long breath among the ice. The short neck is very characteristic.

They rest frequently on large floating masses of tangle, and even the breeding may take place on beds of drifting seaweed instead of on land.

MAMMALS OF THE NORTHERN FOREST

South of the Barren Grounds or tundra there is a belt of forest consisting mainly of conifers, interspersed in the north with birches. There is no sharp line of demarcation; here and there patches of tundra stretch into

the forest zone; here and there groups of straggling trees encroach on the tundra, stately larches grow in the gorges cut by the rivers, and the birches spread everywhere, becoming more and more stunted as they are more exposed. As the forest stretches southwards, mountain-ash, bird-cherry, and alder soon mingle with the pines and birches, other deciduous or leaf-shedding trees appear, and the forest loses its coniferous character except on the high mountains, and finally merges into the Steppes.

The coniferous region shows nothing of the density of the tropical forests. The trees are farther apart, the undergrowth is not so rank, there are no great creepers or lianes and thus, though there are many obstacles, such as fallen trees, in the way of free passage, there are no really impenetrable thickets. Therefore the animals are much less well-marked as forest animals than those of the Tropics. There are indeed many of them that live almost wholly on the trees, but they are not confined to them, and they show no very special adaptations to arboreal life. The great majority of the inhabitants of the northern forest are equally well suited for life elsewhere, and have chosen this haunt for its shelter, for the relative abundance of food, and above all for the stability of the supply.

There is never the extreme luxuriance of plant-growth that makes the steppe a paradise for herbivorous animals in spring and early summer, but neither is there the extreme scarcity which there inevitably follows later in the year.

The capercailzie, blackcock, willow grouse, and other game-birds, which abound in certain localities of the coniferous forests, feed comfortably in spring on young shoots and fresh buds; as summer advances they make daily excursions, often of several miles, to one of the great clearings made by the forest fires, and there they fare sumptuously on the fruits of the many low-growing, berry-bearing bushes which flourish between the blackened tree-stumps. These berries last far into autumn, and there are still the juniper berries and the edible seeds of the cembra pine to fall back upon.

When snow comes the hardy birds burrow down to the

ground at dusk, and remain in these shelters often till high noon the next day. Then they break their way out by beating their wings, and feed, if all else has failed, on the needles of the pines, for some of the branches and twigs have always been blown free of snow. These hardy birds are not without enemies, of course, for the smaller carnivores hunt them ceaselessly, and the larger ones do not disdain them. But there are very few snakes and very few egg-eating mammals, and the birds can baffle the sportsman by their habit of constantly changing their feeding-grounds. Thus, on the whole, the forest offers them very favourable conditions of existence.

The coniferous forest offers shelter and suitable food to many of the larger herbivores, expecially those of the deer tribe, which are typically forest animals. Reindeer and Caribou have each their woodland variety, which grows slightly larger than that which frequents the open tundra. The Maral stag, the Red deer and the Roe-deer occur in the forests of the Old World, Wapiti and Virginian deer in those of the New. But perhaps the most interesting is the largest of all deer, the Elk (*Alcis machlis*) of Europe and Asia, represented in Canada by the similar but rather larger moose (*A. americanus*).

The elk is an uncouth-looking animal with its long legs, short neck, overhanging, prehensile upper lip, and great shovel-shaped antlers. It is intolerant of disturbance, and indeed it appears to become bewildered when surrounded. Thus it has disappeared before the advance of cultivation. But it is still carefully preserved in Scandinavia, and in Russia and Siberia it is well able to hold its own. "A forest animal in the full sense of the word, as much at home in swamp or bog as in thicket or wood, overcoming with equal ease all obstacles of forest and morass, assured by the nature of its diet from the scarcity of winter, it escapes more readily than any other beast of the chase from pursuit either by man or by other dangerous enemies. The latter include wolves, lynxes, bears and gluttons ; but it may be doubted whether all these beasts of prey together very seriously affect the elk. For it is as strong as it is courageous, it has in its

sharp hoofs even more formidable weapons than its antlers, and it knows right well how to use both. It may fall victim to a bear who surprises and overcomes it, but it undoubtedly hurls a single wolf to the ground, and may even be victorious over a pack of these eternally hungry creatures."

The elk is unable to graze on the ground; its short neck and long legs only allow it to reach the lower branches of trees, the tops of bushes, and long grasses. But in summer it spends a great part of its time, especially at night, sunk deep in the mud of the marshes, and there it feeds royally on succulent water-plants, plunging its head into the water to uproot them, and then blowing mud and moisture from its nostrils with a snorting noise that can be heard at a long distance. When the marshes begin to freeze, the elk retreats to higher ground, and must then content himself with a drier diet. The moose of Canada is said to stamp out a "moose-yard" and feed on the bushes all round it, thus securing himself a firm foothold if he is attacked by wolves.

Wherever there are many herbivores there are sure to be many carnivores, too. And all through the "Taiga" of Europe and Asia, and the forests of Canada, the wolf is abundant. How abundant it is difficult to say, for "they are found everywhere and yet nowhere; to-day they fall upon the herds of a village, and to-morrow they ravage the sheepfolds somewhere else; they leave certain districts suddenly and establish themselves in them again just as unexpectedly; here they defy their persecutors and there precautions against them are almost superfluous." In the "Taiga" the wolf does not usually hunt in packs, but a single animal can do a great deal of damage among cattle and sheep.

The Wild Cat, which is still comparatively common in some parts of Europe, and not yet extinct in the North of Scotland, does not seem to occur in Siberia, where the only representative of the Cat tribe, save for rare incursions of the tiger from the south, is the lynx. This beautiful creature is the largest of the "wild cats," and may be as much as four feet in length. The legs are unusually long for a cat, and it stands quite two feet high at the shoulder. The long pointed

ears with a tuft of hair at the tip, and the other tufts of hair on the cheeks, mark it off from others of its tribe. It is clever and wary, and is seldom taken in traps, though it often destroys them. It is content with small game—birds, squirrels, hares, and even mice—and as these are usually abundant in the depths of the forest it has little need to seek the open. "How much the lynx is feared by the game-birds may be seen from the fact that every wooing capercailzie or blackcock is immediately dumb when a lynx lets himself be heard."

In times of scarcity, or when his usual victims have changed their feeding-ground, the lynx comes nearer the fringes of the forest, and then becomes very destructive to larger animals. "Like all Cats, he has not a particularly fine sense of smell, and his pace is not sufficiently rapid to allow him to pursue his prey. His patience, and the skill with which he creeps noiselessly, brings him close up to his victim. More patient than the fox, he is less cunning; less hardy than the wolf, he leaps better and can resist famine longer. He is not so strong as the bear, but he keeps a better look-out, and has sharper sight. His strength resides chiefly in his teeth, jaws, and neck. He is not voracious, but he loves warm blood. . . ." So bloodthirsty is the lynx's nature that a single individual has been known to destroy forty sheep within a few weeks. "The Canadian lynx has been seen to jump on the back of a sheep, and bring it to the ground by repeatedly biting at its eyes."

THE BROWN BEAR

The Brown Bear is a very "individual" animal with a place by himself. He cannot be ranked either with the herbivores or with the carnivores, since he eats both animal and plant food at all times. Except at the pairing season, he lives a solitary life, and wanders through the forest, to which, however, he is by no means confined, molesting no one if he is not attacked, and only exceptionally killing larger animals for food. Yet the popular conception of him as a good-natured beast not without a sense of humour is far from

correct. According to Brehm his good-nature is indifference, and his reputation for humour is due to the drollness of his rolling gait. But this leisurely-looking amble gets him quickly over the ground, and he can break into a gallop that is extraordinarily fast. His long hind legs make it easy for him to go up steep hillsides, but he has to come down warily lest he should overbalance himself. His strong sharp claws are of great help in climbing trees, and he swims well. He is very suspicious and watchful, but he has nothing of the cunning of the fox or the wolf; he prefers to avoid direct contact with man or any other powerful enemy, but if that is not possible he stands his ground, and trusts to his prodigious strength.

His normal way of life throughout the summer is comparatively harmless. He wanders about his own particular beat in the forest, appearing each day at the same point at nearly the same time. His day's round can be read from the tracks and traces he leaves behind him, and it has been described by various sportsmen who have followed them. Here he pulls an ants' nest to pieces and consumes with equal eagerness the fat white grubs and the ants themselves; there a handful of scattered feathers shows that he has made a successful leap upon a covey of game-birds. Reaching a river-bank, he fishes for a while but, food being plentiful, he eats only the head of his victim and leaves the body lying on the bank. Had it been spring-time he would have followed the migrating fishes up-stream for days, but now he wanders back into the forest, bending down the tops of the young mountain-ashes to pull some of their ripe fruits, and picking grubs from under the bark of decaying trees as he goes. Presently he comes to a clearing where he is wont to feast on the abundant cranberries, whortleberries, and bilberries. But the clearing is not far from a human settlement, and it is already occupied by women and children picking the berries. The bear does not retreat, he simply stands still and growls. The pickers do not wait—he knew they would not—and he has no further interest in them. In their haste some of them have upset their baskets or left them behind, and he has his feast without

any trouble. He is satisfied for the time and retires into the forest again to dose the warmer hours away. Towards evening he wakes up hungry again, and at once climbs a high tree to look round. There are no men or dogs visible, and the golden grain is tempting. He makes for the harvest-field, enters it, squats down on his haunches, and pulls down the laden ears all about him. One spot stripped, he pulls himself along, still squatting, clearing and breaking down the grain as he goes.

Then the smell of honey attracts him and he looks about for the hives. The peasants have tried to keep them safe from him and yet let the bees benefit by the flowers at the forest fringe by fastening the hives to a high branch, and stripping the trunk of the tree smooth. But the bear is not easily baulked ; his claws are sharp and his love of honey amounts to a passion. He succeeds in climbing the tree and knocking off a hive, carries it away. It is not easy, for the angry bees swarm all about him and sting him repeatedly in his few vulnerable parts. He puts down the hive and rubs off his tormentors with his paws ; but they return at once ; he rushes to the nearest swamp to rub his burning nose in the cool mud. But he comes back, and in the end he gets his honey.

As winter draws near the bear gets very fat, especially, it is said, if he has taken a journey far enough southwards to add acorns to his dietary. When snow comes he seeks out a hole, a cave, or a hollow tree, lines it comfortably and becomes more or less sleepy according to the amount of fat he has been able to put on. But the bear is no hibernator. The female keeps quiet and is often sleepy just before the birth of her cubs, but after she has suckled them for a little she becomes very hungry and must go forth to forage.

The winter huntsmen often attack the bear in his resting quarters, but it is a dangerous sport, for a disturbed bear becomes mad with rage, and is afraid of nothing. It is at this time that he is most dreaded, for there is little plant food, and he will attack any large animal he can get near. Sometimes, too, the taste for fresh meat becomes too strong,

and the lust for killing grows. When that happens he "becomes a beast of prey in the fullest sense of the word," for he will not only attack elk and other deer, but he will kill the horses in the fields and break into the cattle-sheds to get at the cows. We are told that a bear has been known to lift a newly-killed cow in its forepaws, and to walk upright with it through a brook, and to hoist an elk out of a ditch and drag it half a mile through the swamp.

THE EUROPEAN BISON

For a picturesque and also for a pathetic reason we wish to include among our examples of forest animals the European Bison or Wisent, first cousin of the American Bison. The picturesque reason is that the animal is one of the most impressive of living mammals, standing nearly six feet high at the shoulders, a powerful and fierce creature. The pathetic reason is that this grandiose animal is on the verge of extinction. The Great War left only a few small herds in what might be called a wild state, and most if not all of these have perished in the aftermath.

The European Bison, technically called *Bison bonasus*, has received many names, such as wisent and zambra, and, unfortunately, aurochs, a title that belongs to the Primitive Ox (*Bos taurus primigenius*), which disappeared for ever in the early years of the seventeenth century, perhaps about 1627.

The European Bison, like its American relative, is very massive in its forequarters, highest at its shaggy shoulders, with the line of the back falling from that apex. The head is short, blunt, and depressed; the horns are of medium length, but very strong. The horns and hoofs are black. One gets an impression of great shagginess, for there is a thick covering of long, soft hair, brownish, reddish, and dark grey in colour. There is an almost black brush on the tail, and a beard of the same colour below the chin, which is said, curiously enough, to be most pronounced in the cows and young bulls. There is a change of hair after the first fall of snow, so that the bisons get their warmest suit in the

winter. This is shed very rapidly when the spring thaw begins. The bull's pelage is ruddier in summer than in winter; the cows change from ruddy-brown to dark grey. The skin has a musky smell, which also affects the flesh.

The bison was once widespread throughout Europe, including Britain; it probably extended into Asia Minor, perhaps even to Turkestan, and, according to Lydekker, there are bones in Canada and Alaska that belong to the European, not to the American, species. With the cutting down of forests, the spread of agriculture, and the growth of civilisation, the range of the splendid animal was in the course of centuries more and more restricted, until at the beginning of the nineteenth century it was represented only in the forest of Bialowieza, in Lithuania, and in some of the wooded parts of the Circassian mountains. The bisons of Bialowieza were said to number about 300 in the early years of the nineteenth century, and more than twice as many in 1914; but while the Napoleonic war left a sturdy remnant, the Great War left none, or, some would say, seven, which have since perished. Some small herds were left in the virgin forests of Circassia, but it seems that they also are now gone.

The bison is pre-eminently a forest animal, though it may leave its retreats in search of pasture. It dislikes the heat and the glare, but in upland forests it often enjoys the fresh coolness of open spaces near streams where there is a thick growth of butter-bur. Bison like to roll in the sand, and there used to be short slopes called "totchki" on the Circassian mountains, where they slid down on their backs for two or three yards. They can ascend to 5000 feet or so, but they do not go beyond the end of the trees. They seek lower levels in winter when the snow is very deep and the frost keen.

Bisons go about in small herds of cows and young males, usually six or seven in number, occasionally over a score. The old bulls live alone in the forest, except at the breeding season, when they take command of the herd. There are many stories of the bad behaviour of these "solitaries" —how one will eat up the peasant's hayrick and another his

potato pit, how one will lie down for the day across a road and refuse to budge even for the Forest Commissioners, and how another becomes like a "mad bull," requiring little in the way of "red rag."

A bison can smell a man from a distance of 200 yards, and is also quick of sight. There are so many little noises in the forest that the sense of hearing does not seem to count for much, unless it is much more acute than the bison's. Its voice must be a terror; it has been compared to thunder, to a discharge of firearms, to the grunting of a pig. If these comparisons are all appropriate, the bison must have a considerable range of vocal expression! It seems to say "Too-oo-oor" very loud. In exceptional cases there is a melancholy moo, as when a cow-bison has been robbed of her calf, and is sometimes as dangerous as the savage bull.

The staple food is grass, notably sweet vernal, the fragrance of which is said to be discernible in the flesh and in the thick milk. There seems to be fondness for plants that have a good deal of flavour, such as the bitter buttercup, the marsh marigold, the meadow geranium, and the balsam. In winter the bisons have to depend on harder plants, such as thistles and brambles and ling, and they often tear the bark off the trees.

The pairing is usually at the beginning of September, and the rival bulls fight furiously. A young aspirant of three years old is often killed by an older bull. On one occasion the two combatants were so preoccupied that the firing of several shots did not interrupt their encounter, and we read that a third bull arrived on the scene, tore up a sapling four inches in diameter, twisted it up in his horns, and charged the others with the tree on his head! "Quand la poussière se dissipa il n'y avait d'animaux."

The cow-bison has a calf when she is five or six years old, and she gives birth in May or June. But two years must elapse before she bears again, and the probable explanation is that she suckles her calf for the great part of a year, as in the case of the American bison, and does not rejoin the herd until the safety of her offspring is for the time being secure.

But there is great discrepancy in the accounts that are given of the relations between cow and calf, especially as regards the courage or timidity of the mother and the precocity or feebleness of the offspring. It may be that there is considerable variability. The length of life is probably thirty to forty years for the cow-bison and fifty for the bull. But unless something is done speedily the European Bison will be an animal of the past (1932).

For many years the poacher was the bison's worst enemy in the North, in spite of punishment by death (as a formal sentence) under the Polish Government, and deportation to Siberia (afterwards changed to a huge fine) under the Russian *régime*. But now, as we have said, there are no more northern bisons to be poached. Collectors of heads have for long been ruthless in Circassia, and the Bolshevists seem to have finished off the small post-war herds by using mitrailleuses. Apart from man, the only serious enemies of the bison have been wolves and warble-flies. No doubt there have been occasional outbreaks of microbic disease and occasional bad infections with liver-fluke, but it is not through any casualty of this sort that the bison has been brought to the verge of extinction. For that is due to man alone.

The question rises whether man, thoroughly ashamed of himself, might not make a fresh start with bisons. The Duke of Bedford has a small herd at Woburn Abbey; the Zoological Garden at Budapest had seven in 1922; the Zoo in Berlin had five in the same year; and Sztolcman knows altogether of twenty-eight still living in similar conditions. It is possible that there is a total remnant of seventy, and the hope is entertained that it may be possible to re-stock suitable places with this splendid type. It is to the lasting credit of Dr. William T. Hornaday, of the New York Zoological Gardens, that he has saved the American Bison from immediate danger of extinction. Through the efforts of his Bison Protection Society the numbers were raised from about a thousand in 1889 to over eight thousand in 1923, and by similar skill and enthusiasm the European Bison might still be reinstated. Its reduction to between

thirty and seventy individuals leaves little margin, but the endeavour is certainly not hopeless. The European Bison is an antique type with splendid qualities, doing little harm and with usefulness in every inch of its body. Must it follow the Aurochs to extinction? This would be a disgrace to civilisation. Let us hope that it may be avoided.

THE MAMMOTH

Early in the nineteenth century the bones of the mammoth, thawed out of Siberian bogs, were described by the great Cuvier as those of a big northern elephant. Before that they had been badly misunderstood, for some held them to be the remains of a race of giant men, and others regarded them as huge burrowing animals that died at once if they were by any chance unearthed. The puzzle was increased when the finds included not only the bones, but pieces of shaggy skin and chunks of frozen flesh at which the hungry dogs began to gnaw. In 1806 the intrepid explorer, Adams, secured an almost complete frozen mammoth on the banks of the Lena River. Though it must have been in cold storage for thousands of years, the flesh was being eagerly devoured by wolves and polar bears that came from great distances to the strange feast. Some bold native had sawn off the ivory tusks, but most of the bones were available, and Cuvier did not require any genius to know that he had to deal with a species of elephant. A number of mummy mammoths have since been found, and we actually know a good deal about the tongue and trunk, the stomach and blood, of this giant mammal long since extinct.

As compared with a modern elephant, the mammoth had a very bulky head, a shorter but more massive body, a shaggy hide, and in the male huge recurved tusks, often bent round to fully three-quarters of a circle. The largest mammoth tusk in the Petrograd Zoological Museum has a length of thirteen feet seven and three-quarter inches. A formidable weapon indeed, but probably to be regarded as an expression of intense virility which was carried to an extreme, like the enormous antlers of the so-called Irish Elk.

One of the mammoth carvings made by Aurignacian man on the walls of caves shows two finger-like processes at the tip of the trunk, and we may be almost sure that this was the case. But the trunk of the mammoth was not nearly so large or strong as that of either the African or the Indian elephant, and its chief use was doubtless that of gathering grass and sappy herbage in the Arctic meadows.

In a very interesting recent study of the mammoth, Mr. Herbert Lang, of the American Museum of Natural History, argues from the surface of the huge molar teeth that the mammoth fed on " rather tough, but very nourishing, boreal meadow plants." He contrasts this diet with that of modern elephants that swallow bulky succulent masses of tropical vegetation. Thus a more compact diet would allow the mammoth to dispense with immense alimentary organs, in this way keeping the body, behind the head, rather shorter. As to mammoth's food we are not left to conjecture, for there has been an actual identification of parts of plants found between the teeth and in the stomach of Siberian mammoths. They represent plants that are found in the same country to-day—five kinds of grasses, such as foxtail, two kinds of sedges, wild poppies, the seeds of a buttercup, the pods of a vetch, and wild thyme for flavouring. It is quaint to think of the mammoth looking for a " bank whereon the wild thyme blows " !

In his study, already mentioned, Mr. Lang makes out a good case for regarding the mammoth as given to rambling. Many of the herbivores move about in search of pasture, and it is probable that the mammoths wandered hither and thither through most of the northern countries of Europe, Asia, and America. They have left their bones in many parts of Great Britain; they are found as far south as Spain and Italy, California and Carolina! A trapped mammoth must have been a winter godsend to Palæolithic man. A human appreciation even in those early days reached far beyond the cupboard: witness a child's necklace of mammoth ivory beads found at Predmost in Moravia.

Mr. Lang discusses the old puzzle of the large number of mammoth bones sometimes found together. Thus no fewer

than eight hundred individuals have been found at Predmost, and there are other crowded graveyards. The occurrence of innumerable stray skeletons is readily intelligible, but why should there be a great many together? One can only conjecture that the members of a large herd trekking in search of pasturage became ensnared in boggy ground from which they could not extricate themselves, or were smothered in a snow-storm, or were surrounded in a river-flood, as horses sometimes are, and were drowned. "Or did furious gales and blizzards cover them alive with icicles that quickly grew to encasing blocks of ice?" In some cases "the cramped position, broken bones, large amount of clotted blood in the body cavity, as observed in the Beresovka mammoth, point, as Salensky shows, towards instantaneous death by accident. The victim did not even have time to throw out or swallow the quantities of fodder between its molars and in process of mastication."

In any case the herds of mammoths dwindled, though the trade in their ivory continues. They were highly specialised, slow-breeding masterpieces, adapted to boreal conditions and unable to change. It is not necessary to suppose that something went wrong with their hormones, though that may have been. Like many other giants, they had their day and ceased to be.

V

ARBOREAL MAMMALS

THE Red Squirrel is very common throughout Great Britain, though in Scotland it was almost entirely driven out about a century ago by the persistent cutting down of the forests. But it was reintroduced at various points, simply because of its beauty and its fascinating ways. Year by year it became more abundant, until in some wooded districts it could be only regarded as a " pest," and measures had to be taken for its destruction. But we need not here dwell upon this aspect of things. If we really wish to understand the life of wild animals, we must learn to look at it from their point of view and not from our own.

And what a jolly life the squirrel's must be ! What fun he seems to be having as we watch him running up the trunk of a tree, peeping out at us from behind it, waiting till we come near, and then running out to the end of a branch, springing lightly across a space to another one, and disappearing among the dark pine-tops. And how pretty he looks as he sits erect, his tail turned up behind him, at the foot of a tree, holding a bit of toadstool in his deft forepaws, and daintily tearing bits off it with his teeth. Sometimes he prefers to take his meal on the top of a log or a flat stone, and there he sits, his bright eyes watchful, his whole body alert, skilfully pulling off the scales from a fir-cone to get at the palatable seeds. At the first hint of intrusion he drops his half-eaten cone on his already littered table, and is away like a flash to the nearest tree.

Most charming sight of all, but not so easily seen, is a mother squirrel carrying her baby carefully in her mouth across a stretch of grass between one belt of woodland and another. She is transferring her family, one by one, from the comfortable " drey," where they were born and suckled,



Photo : F. W. Bond

RED SQUIRREL : BOHEMIAN VARIETY.

This is a near relative of the common British squirrel, with a heavier tail. As winter approaches, it has a rich nut-brown colour, and the ears begin to show tufts. In spring the winter-dress is considerably worn and faded. The new summer coat is redder and shorter.

to a new home less exposed to danger, or, it may be, nearer to an abundant food-supply. She will have to make several journeys before she has finished her " flitting." There are usually two or three young ones, and as the survivors will be ready to have families of their own the following spring, it is little wonder that squirrels may become too numerous in the woods. It should be noted that there is not a little education of the young squirrels by their parents ; they are taught gymnastics and the long alphabet of woodcraft. The squirrel's main food is the seeds of pines, acorns, beech-mast, and hazel nuts, but in spring he bites the young buds off the larches and he gnaws the bark of the young tree-tops in a ring to get at the sweet sap flowing downwards underneath. As he bites right through the bark and into the young wood the ascending sap, which goes up that way, is checked in its progress and all the tree above the ring must die. For the ascending sap contains the quite indispensable soil-water and salts on which the plant depends.

Like most rodents, the squirrel will take animal food if occasion offers. He eats both the young and the eggs of wood-pigeons, and thus to some extent gives back to the farmer what he takes from the forester. Unfortunately he robs the nests of singing birds as well.

Towards autumn the squirrel begins to gather stores of nuts, acorns, and the like. Some of these he hides in his hole near the foot of his favourite tree, and these will satisfy his hunger when the weather is wet, or the frost very severe. He does not sleep through the winter, but he often remains in his hole for two or three days at a time. He is sometimes drowsy, but he is not a true " winter-sleeper."

Other stores are buried in many different places in the flat ground or on a bank often at some distance from the nest, and these are so carefully covered over that it is often thought the squirrel can never find them again. Mushrooms and toadstools are gathered but not buried, for they would very quickly decay in moist soil. They are carried up into a tree and firmly stuck into a cavity, or into a fork between branches, where they will remain quite dry. So the squirrel puts brains into his storing.

The squirrel is apt to be very wasteful in his methods, and " will destroy a whole bush for the sake of half a dozen nuts." Two squirrels were observed working busily at a copse of beechwood, going out very nearly to the end of quite thin branches, where they hung by the hind legs while they stripped off nut after nut, many of these falling to the ground, more or less lost spoil. Squirrels often engage in this work-play for hours, for they are untiring.

An American observer watched the Grey Squirrel—a near relative of our red one and now threatening to oust it in some parts of England—bringing down nuts one at a time in his mouth. He scraped a hole about two inches deep, dropped in his nut, pressed it firmly down with his forepaws, covered it with earth, and pulled the grass over the spot, so that no trace of his work was visible. But the same observer saw squirrels running about over two inches of snow in winter. From time to time one of them would suddenly stop short, begin to scrape, and then " dig up a nut with unfailing precision." So the squirrel may not be so happy-go-lucky as he seems. He knows that he can trust to his very delicate sense of smell to guide him to the numerous stores he has laid up. It is interesting to remember how the Northern people believe the reindeer can " smell by his feet," for it shovels off the snow at profitable places. But it smells by the nostrils as usual.

There is something unusually attractive about the squirrel. It is petite without being pigmyish ; the bushy tail balances the body ; the rich brownish-red upper colouring is very pleasing ; its alert attitude when watching you is prepossessing ; its table manners are perfect as it unshells the kernel of the nut, and, as MacGillivray observes, " even removes the outer pellicle before munching it." But the movements take our breath away, we do not know whether to admire most their gracefulness or their daring.

In the summer we startled one as it was eating a nut or perhaps a toadstool ; it covered the ground in a succession of leaps so quick that we could only see the result ; it ran up the tree as if it did not need to hold on ; it vanished to the

other side, and looked round at us ; and as we came near it ran along a branch, on to the very end, and then it was on another tree. If need be, it can remain quite motionless, pressing its body against the trunk. When it sleeps it uses its tail as a blanket.

Apart from man, who naturally resents the way the squirrels bark the trees or eat off the topmost shoot, these attractive creatures have few enemies, for it is rarely that a stoat or a hawk gets even a youngster. This security probably adds to the natural gaiety of their disposition, and there are few animals that give us a stronger impression of the joyousness of life. They recall Walt Whitman's lines :

> " They do not sweat and whine about their condition. . . .
> Not one is respectable or unhappy over the whole earth."

If tamed when young, they make delightful pets, especially if they are allowed to come and go, which should, indeed, be a condition of keeping an animal so instinct with freedom. Squirrels are among the playing animals, and have a game of " tig " on the trees. We do not suppose that they are very clever—their brain does not point in that direction—but they are charmingly joyous.

THE TREE-SLOTHS

Among the most old-fashioned of arboreal mammals are the tree-sloths of the South American forests. They move slowly about, hanging with the long curved claws of their hands and feet to the under-side of the branches. In this posture, back downwards, they also rest and sleep. They are very awkward on the ground, but they never come down if they can help it ; they are even more arboreal than monkeys.

There is something antediluvian about these tree-sloths, and we know that they are survivors from very ancient days. They are slow in moving, slow in eating, slow in dying. Their rough, shaggy hair is like the " vegetable horse-hair " of some of the perched plants of the forest, and it has a



Photo: W. S. Berridge, F.Z.S.

TWO-FINGERED TREE-SLOTH (*Cholœpus didactylus*).

This old-fashioned arboreal mammal lives in South American forests. As is seen in the photograph, there are only two fingers; but there are three toes. The hair is long and shaggy, and bears minute Algæ, which give it a greenish colour. Thus the animal is inconspicuous on branches covered with hair-like lichen. It creeps along back downwards.

strange greenish colour. There is a minute green Alga that grows on the rough hair of the Sloth, just as some of its allies grow on rocks and on the stems of trees. We all know the green dust which comes off on our clothes when we rub against a beech tree in damp weather.

The Tree-Sloth is seen at a great disadvantage on the ground, and it rarely seems to have any idea of resenting treatment. Mr. Oswald writes that the Mexican species surrenders at discretion to all his enemies, great or small. " He permits you to lift his claw, but drops it as soon as you withdraw your hand. If you prod him he breaks forth in a moan that seems to express a lament over the painfulness of earthly affairs in general rather than any resentment of your particular act. If a dog bites him, or if you offer him a titbit after a prolonged fast, and snatch it away from his very jaws, he will slowly turn his head, and then, as if the significance of the indignity were gradually dawning upon his mind, he breaks forth into crescendo grunts, resembling at once the whir of a buzz-saw and the droning hum of a bee-hive." In the *Riverside Natural History* (1888), from which we have quoted these lively sentences, the forest cry of the Tree-Sloth is described as " a long drawn, tremulous moan, not unlike the wail of the whip-poor-will or a lugubrious variation of a watch-dog's yelp."

There are different kinds of sloths, two-toed and three-toed, and each kind has its favourite diet of leaves. Thus the Mexican two-toed sloth keeps almost wholly to leathery leaves with a milky juice, while the three-toed kind is fondest of the leaves of a tree called Cecropia. When one native reproaches another for idleness—the pot calling the kettle black—he says, " You beast of the Cecropia tree." But the important point is that there is a tendency among many animals to become " specialists " in what they eat, whereas others—take the otter for instance—have a very long bill-of-fare. Both ways work ; the first lessens competition with other hungry creatures ; the second opens up numerous possibilities, for if one kind of food fails, something else can be sought for.

The great French naturalist, Buffon, who died in 1788

(the year before the French Revolution), was greatly interested in the Tree-Sloths. But he quite misunderstood them, for he took them as examples of Nature making a mistake. "One more defect," he said, "and they could not have existed." Slow, quaint, queer, awkward, they may be, but they are extraordinarily well fitted to live among the branches. There is, for instance, a touch of perfection in the peg and socket ankle-joint, so well suited for turning and twisting about. Then there is the way in which the mother, moving as usual back downwards along the underside of the branch, carries her single baby on her lap, as safe as safe can be.

Let us take a picture from *The Naturalist of the Amazons* (1864), by Mr. H. W. Bates, one of the great naturalist travellers. Speaking of the Three-Toed Sloth, he says: "It is a strange sight to watch the uncouth creature, fit production of these silent shades, lazily moving from branch to branch. Every movement betrays, not indolence exactly, but extreme caution. He never loosens his hold from one branch without first securing himself to the next, and when he does not immediately find a bough to grasp with the rigid hooks into which his paws are so curiously transformed, he raises his body, supported on his hind-legs, and claws around in search of a fresh foothold."

THE SPECTRAL TARSIER

One of the most interesting of all tree mammals is the little Spectral Tarsier of the forests of Borneo, Java, and the Philippines. It is interesting in its structure and behaviour, still more in its relationships and its promise. It is a unique creature (*Tarsius spectrum*), the only species of its genus, and the only living representative of its family—a family which perhaps gave origin to the lowest true monkeys. Some call it a lemur or half-monkey, but it differs widely from all the members of this order. It seems more monkeyish than half-monkeyish.

You can hold a spectre on the palm of your hand and its baby at the same time. The body is about six inches long,

the tail two or three inches longer. There is a thick, woolly fur, brownish-grey above, lighter below. An extraordinary elongation of two of the ankle-bones, reminding one of the frog's foot, makes the hind leg disproportionately long, and this is well suited for jumping from branch to branch, or from one bamboo stem to another. In its dainty body the Tarsier recalls the bipedal Jerboa, which also stands high on its hind-legs (anatomically different, however), and has a very long rudder-tail ending in a tuft. Another strange feature is the development of circular cushions at the ends of the fingers and toes, helping the Tarsier to grip the branches. They are curiously like the adhesive discs on the digits of tree-toads, thus illustrating convergence, or the occurrence of similar adaptations in unrelated types.

The most striking feature, however, is the bigness of the eyes, which are relatively huge circular discs, directed forwards, gleaming yellow at night. The head, very mobile on its short thick neck, has been compared to a two-lensed lantern, movable in all directions on a ball-and-socket joint. The reduction of the snout, natural enough in an arboreal animal, beginning to have a free hand, has brought the eyes to the front of the face. But the experts tell us that while Tarsius has binocular vision, it is not yet capable of appreciating stereoscopic effects. It is not yet able, Professor Elliot Smith says, to appreciate the texture or the details of the things seen. "For this purpose it is necessary to be able to move the two eyes in any direction in the closest co-ordination the one with the other." Tarsius has not got this length, but it seems to feel the need of it. For it has the power of moving its head upon the vertebral column through an extraordinarily wide range. With its body pressed against a branch, it can turn its head almost to the extent of 180 degrees and look backwards. "This means that Tarsius feels the need of moving its two eyes in co-operation the one with the other, but as it lacks the necessary range and precision of conjugate movements, it moves its head much as a cat does, and so roughly achieves its purpose of bringing the two eyes at the same distance

from the object." The Spectral Tarsier must be hailed as a pioneer in precise vision; and for the animal itself this is of great importance, for it is a crepuscular and nocturnal animal, catching its prey in its mouth as it jumps, and needing all the precision its eyes can give it in the dim light.

The spectres sleep during the day in holes in the trees, and are naturally rather cross when wakened up. At night they hunt for small animals, such as insects and lizards, and their moving about is singularly noiseless. They have not much to say to one another, but utter now and again a sharp shrill call. They live in pairs, monogamously, and with few exceptions there is but one baby at a time. It is able to hold on to its mother's legs, but Dr. Hose has seen one being carried in the mouth like a kitten. Almost from the first, the spectral pickaninny is able to climb, but it likes to be carried, and the mother is not unwilling.

The Tarsier seems fascinating to our eyes, but the natives regard it with horror. Is this because of its quaintness of build, or its huge goggle eyes, or the uncanny silence of its movements? Professor Elliot Smith suggests that the people of Java and Borneo have "a sort of instinctive horror at the sight of the ghost-like representative of their remote Primate ancestor!" But this is perhaps too subtle; for although technical zoological science strongly supports the view that Tarsius connects Lemurs and Monkeys, and is more or less in the direct ancestry of the latter, this is not the sort of thing "natives" bother about.

One of the most impressive diagrams ever published is that in which Professor Elliot Smith, in his recent *Evolution of Man* (1924), makes a comparison of the brains of Jumping Shrew, Tree Shrew, Tarsier, and Marmoset—the last being the most primitive type of living monkeys. The Jumping Shrew is a terrestrial animal with comparatively poor brains. Its life is dominated by the sense of smell, and the smell-perceiving region of the brain is relatively enormous, while the centres for sight, hearing, taste, to[illegible] and the control of precise movements are diminutive. [illegible]hen its cousin the Tree Shrew became arboreal a p[illegible]nsformation was effected. We speak of being "[illegible]t no step

has meant more in evolution. It implied a gradually setting free or emancipation of the hand, a reduction of the snout, a bringing forward of the eyes, an enlargement of the brain-case, and an increasing complication in the roof of the brain, with its centres for vision, hearing, touch, and skilled movements.

It may be objected that there are arboreal marsupials which cannot be called clever; the answer is that their brain is built on lines somewhat different from that of ordinary mammals which possess an adaptable and unifying region, the "neopallium." It may be objected, again, that there are many intelligent mammals that are not arboreal. The answer to this is that there are possibilities in a monkey's brain that surpass the achievements of dog, horse, and elephant. The special interest of the Spectral Tarsier is that its brain shows a great extension of the visual territory and a marked reduction of the olfactory territory of the fore-brain. This becomes still more striking in the Marmoset, where, besides an enlargement of the centres for sight, touch, hearing, and motor control, there is a strengthened development of an area (called prefrontal) which has to do with securing manipulative skill, stereoscopic vision, and mental as well as ocular focusing. Along precisely similar lines the Tree Shrew rises above the Jumping Shrew, the Tarsier above the Tree Shrew, the Marmoset above the Tarsier, the ape above the Marmoset, and man above the ape. Professor Elliot Smith's conclusion is that the cultivation of vision has played an important part in the evolution of man's intellect. Does this not mean that success is to the visualisers, that clear seeing leads to clear thinking? In any case, we find food for thought in that little squirrelish, shrewish, monkeyish, goggle-eyed Spectral Tarsier—a pioneer in seeing things clearly.

OPOSSUMS

An interesting arboreal type, confined to the American forests, is the opossum. It belongs to the same group as the little tree-kangaroo, which, like the big ground

kangaroos, has a pocket of skin for carrying its young ones. The opossum is very different from the round-headed, stumpy-tailed sloth; it is a somewhat rat-like, active little animal, with a very long tail, which it can hook round the branches. Its feet, too, are well suited for grasping, for the great toes are opposable to the others so that a branch can be firmly held between the big toe and the rest of the foot. As the little mouse-opossum scrambles about on the trees in search of the insects that are its chief food, it carries its babies on its back. They are quite safe, because the mother keeps her long tail curved forward above them, and they "strap-hang" to this support by twisting the ends of their little tails around hers.

W. H. Hudson, the naturalist, wrote of a larger kind of opossum: "I have seen an old female opossum with eleven young, large as old rats—the mother being less than a cat in size—all clinging to various parts of her body; yet able to climb swiftly and with the greatest agility in the higher branches of a tree. . . . The opossum never quitted its hold on the tree, and it also supplemented its hand-like feet, furnished with crooked claws, with its teeth and long prehensile tail." Opossums frequently come down from the trees, and when they are on the ground they are known to make use of the "roads" trodden smooth by processions of ants making their way through the forest.

Many different kinds of animals have found that taking to the trees is the solution of the problem of finding a livelihood. It gives new opportunities of feeding and of nesting, and new possibilities of movement. It is interesting to find the same kind of adaptations to life in the trees in animals of widely separated groups. In the opossum which is a mammal, and in the chamæleon which is a reptile, there are marked points of similarity. Thus both have long tails, admirably suited for coiling round the branches, and both have feet more or less cleft in two parts for gripping purposes.

We have seen how necessary it is to the sloth that the trees among which it lives should be so close together that it can swing from one to another by means of its long arms,

but in many forest regions there are gaps between the trees. This means that the animals must take to the ground if they wish to travel, or else use some other method of bridging the chasm. So we find that in several quite different groups of animals there are attempts at flight.

Birds may often be seen " planing " down from a great height, without a single beat of the wings for a long time ; this kind of movement is the same as that of the " parachutists " of the trees. It is a sort of prelude to true flight. The " flying squirrels," for example, have fur-covered skin stretched from limb to limb, making an effective " plane." There are all sizes of planing squirrels, down to one that is only three inches long, but a typical one is the brown flying-squirrel, an animal not unlike our own squirrel, except for the additional parachute. It has a long, bushy tail, which helps it to keep its balance, and the skin extends from wrist to foot along the sides of the body. When the limbs are spread out this flap of skin is stretched to make a plane. The squirrel cannot move its " wings," but by movements of its body and tail, it seems able to steer at least a little. As the animal has only a parachute, and no true wings, it cannot fly upwards, but it launches itself boldly from the top of a high tree, and planes across a gap to another tree, where it lands at a lower level.

The movements of the American flying squirrel have been thus described : " At times one would be seen darting from the topmost branches of a tall oak, and with wide extended membranes and outspread tail gliding diagonally through the air, till it reached the foot of a tree about fifty yards off, when, at the moment we expected to see it strike the earth, it suddenly turned upwards and alighted in the body of the tree. It would then run to the top, and once more precipitate itself from the upper branches and sail back again to the tree it has just left. Crowds of these little creatures joined in these sportive gambols ; there could not have been less than two hundred."

Other observations, for instance of the flying lemur (Galeopithecus), whose parachute extends even to the tip of its tail, show that the planing animals can cross a gap many

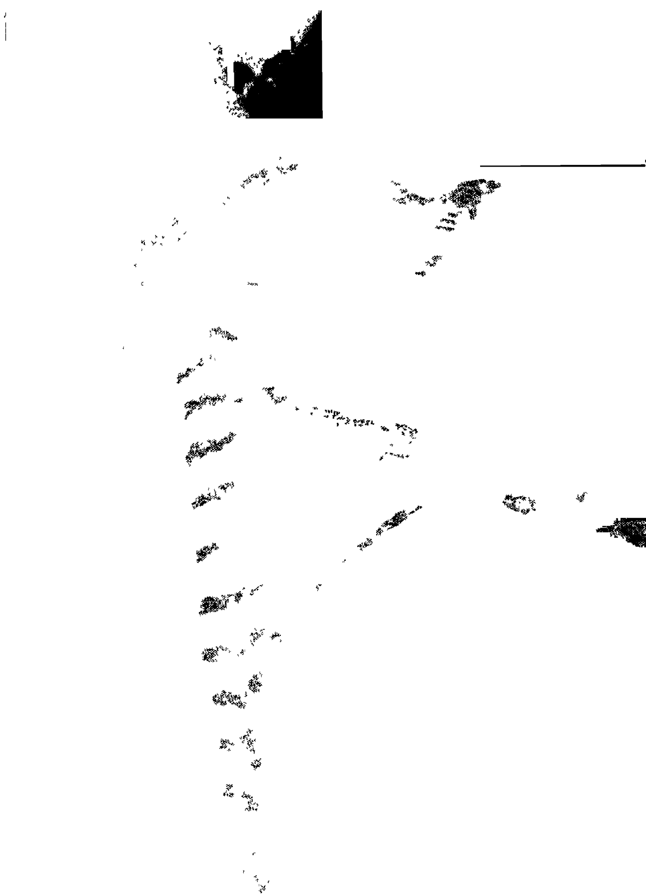


Photo : Harold Bastin.

RING-TAILED LEMUR (*Lemur catta*).

This gentle creature lives gregariously in Madagascar forests, often among rocks and bushes rather than on trees. It is active and graceful in its movements, and utters a plaintive cry like a domestic cat. Its general colour is delicate grey, but the tail has alternate rings of black and white, as the photograph well shows.

yards wide, and also that, though they cannot fly to a higher level than their starting-point, they can guide their course and even make a slight upward movement while they are in the air. The same type of parachute is seen in mammals of very different groups—Insectivores and Rodents—and also among the pouched mammals.

VI

AERIAL MAMMALS

THE spirit of Nature must surely have smiled when bats evolved from climbing and swooping insectivores, for it is practically certain that this was their origin. Are they not incomparably quaint creatures, hanging themselves up by their toes, wrapping themselves in their arms ? They have solved the problem of flight, but their solution is quite different from that of birds, coming nearer what we see in the extinct dragons or pterodactyls. They are mammals through and through, covered with hair and giving milk to their young, and yet they are as aerial as most birds. Like whales that breathe dry air in spite of their pelagic habit and prolonged immersions, like duckmoles which break down the definition of mammals by laying eggs, bats illustrate Nature's capacity for making a contradiction in terms a great success.

It is interesting to think over the adaptations of bats to aerial locomotion—a successful venture which has reacted (in a way difficult to think out clearly) on old-established structural arrangements. There has been an extraordinary *correlation of variations*. The extension of silky skin that forms the pliant, elastic wing-membrane begins at the side of the neck, passes along the anterior surface of the arm, skips the clawed thumb, and is stretched out on four very long fingers, of which only the first has ever a claw, and that only in a small minority. From the posterior surface of the arm the membrane reaches along the sides of the body and is continued down the leg as far as the ankle. An accessory membrane, usually in part supported by a gristly or bony yard-arm, arising from the ankle, extends between the hind-legs, including the tail if there is one. The wing-membrane has drawn the leg strangely outwards ; and the knee points, not forwards, as in all other mammals, but backwards. This

is another of the anatomical whimsicalities of bats. The long bones are very lightly built, with large marrow cavities; the shoulder-girdle is strongly developed; the breastbone has a prominent keel for the better insertion of the powerful muscles of flight; the vertebræ of the back are but slightly movable on one another and become partly welded together with advancing age—a peculiarity also seen in flying birds, and of obvious advantage in giving the wings a firm, unyielding fulcrum against which they can deliver their stroke.

Compared with the fore-limbs, the legs are extremely weak, and it goes without saying that a bat cannot stand up. Although it usually alights on its resting-place head upwards, and may remain fixed by its thumbs, the commoner position when at rest is head downwards, clinging by the well-clawed toes of both feet or of one. When it shuffles along a branch it pushes itself forwards with its feet, which are turned forwards and inwards, and hauls itself onwards on its wrists with the help of the clawed thumbs. It uses first one foot, then the corresponding thumb, then those of the opposite side. We are reminded of the description in the Mosaic law—"the fowl that creeps, going on all fours." When we watch a bat quietly resting on all fours, we notice that the knees are turned upwards and that the elbows are touching them—a quaint posture. It should be noticed that there are some bats which do not hang themselves up to sleep, but lie stretched out.

Bats can launch themselves into the air even from off the ground, and their flight is masterly. In a room they are wonderfully clever, avoiding obstacles such as readily capsizable ornaments, diving under a sofa, and looping the loop; in the open air they vie with the birds—the doublings are so rapid, the disappearances so baffling, the somersaults so sudden, the captures of moths and gnats and flying beetles so unerring, and all so noiseless in spite of what the poets have said about "whirring wings." Some bats can even drink from the river while on the wing, but there are of course great individual differences—thus, a serotine is leisurely compared with a noctule, and a pipistrelle is vacillating compared with a horse-shoe bat. When

"scouting bats begin their giddy round," they utter thin, high-pitched cries, which are sometimes, as in the long-eared bat, such "needle-points of sound" (as Phil Robinson neatly puts it) that many observers with quite normal hearing fail to catch the note. In other cases, however, as in the noctule, the querulous sharp cry is easily heard; and the fox-bats of the East chatter volubly like monkeys.

The accessory (*interfemoral*) membrane between the legs is best developed in the long-tailed insectivorous bats, and helps them to double quickly in the air when hunting moths, and also serves as a sort of bag to which booty may be consigned. In a few cases there is an actual pouch on the membrane. In many cases when a bat has caught an insect in mid-air, it bends its head downwards and backwards, and presses its booty against the interfemoral membrane, giving a bite or two or swallowing without risk of loss. In so doing it sinks a little in its flight. In the fruit-eating bats the tail is small or absent. Most bats are small, delicate creatures, but they have a relatively big chest capacity, a strongly developed heart, and large lungs—a triple fitness for flight. It goes without saying that they are on an evolutionary tack quite divergent from that which birds have followed, but it is interesting to notice the numerous "convergences," similar adaptations to similar problems—*e.g.*, the hollow girder type of long bone, the fusion of dorsal vertebræ, and the keel on the breast-bone.

According to old experiments, bats with bandaged eyes can fly about in a room without touching threads strung across it, can traverse a crooked passage without knocking against the sides, and can detect from some distance the approach of a man's hand. This extraordinary telepathic tactility has its seat in numerous touch-spots at strategic places, and in numerous sensitive hairs, each with a nerve-fibre entering it, which are distributed on the rather bare skin of the wings, on the sides of the muzzle, and on the delicate ear-trumpets, which often have accessory flaps. If we make sounds near a captive bat we can see the tremulous movements of the ear-pinnæ—such a contrast to our own—which are oriented independently of each other. In no

creatures save bats would we find what we see in the common Long-eared Bat—ear-trumpets almost the size of the rest of the body. What, as Bell said, would we think of that in a donkey ? It is difficult to know what to say about the nose-leaves which often adorn or at least distinguish the region of the nostrils, except that they are very original. They may be like horse-shoes, masks, bulldogs' faces, fleurs-de-lis. As Phil Robinson wrote : "Is not a word of gratitude due to a creature that has ventured upon such originality in the matter of nose ? . . . it is always fantastic and unexpected. It is the very orchis of noses." It is an instance of extravagant development, but the significance of the nose-leaves seems uncertain. They may be connected with the extreme "touchiness," but the minute study of them has not revealed, as far as we know, any very special innervation.

The large fruit-eating bats, with the tail rudimentary or absent, with the crowns of the cheek-teeth smooth or with a longitudinal groove, are confined to the warm parts of the Eastern Hemisphere. The largest, *Pteropus edulis* of Java, has a spread of wing of five feet, about half that of an albatross. The great majority of the smaller bats are strict insectivores, but in the family of "vampires" there is a remarkable diversity of diet—some mix fruit and insects, others suck the blood of frogs and mammals, others living by the shore condescend to crabs and fishes. All the insect-eating bats have the crowns of the cheek-teeth covered with sharp cusps like mountain-tops, as in shrews and other insectivores, an obvious adaptation to the better crunching of booty. Bats' hunting is mostly in the air, but there is often a sort of hovering among the branches from which moths and other insects are picked off. In some cases the bat hunts afoot, shuffling along the branches, and then it has been noticed that the interfemoral membrane, with the tail up the middle of it, is directed downwards and forwards and forms a bag into which the booty caught by the mouth is hastily thrust for subsequent consideration. So another of the bat's quaintnesses is making a pocket of its tail !

The small bats of northern countries solve the problem of winter, when insects are conspicuous by their absence, by passing into a state of true hibernation—which is confined to a few mammals. Their "warm-bloodedness" breaks down, and they sink into coma, with breathing movements scarcely perceptible, and with the heart beating only some twenty-eight times in the minute. Even in summer, though their temperature is constant, which is what is meant by "warm-blooded," it is much lower than that of typical birds; in winter it sinks until it approximates to that of the confined space in which the bats hang, often in crowded clusters, it may be over a hundred together. There is something almost eerie in the sight of these inert winter-sleepers, who a few months before were racing with the swifts in the summer twilight. The northern bats solve the problem of winter by falling asleep in a hollow tree or in a corner of the church tower, or under the thatch of barns, or in a crevice in a cave; the swifts and swallows and most of our British birds give a very different, but equally effective, solution by migrating to "coasts that keep the sun." But while no bird hibernates, there are bats that migrate. Thus the Hoary Bat of Newfoundland migrates all the way to the Bermudas, across at least six hundred miles of sea; and one specimen, probably ship-borne, has been caught in Scotland. In connection with the winter-sleep, which all British bats illustrate, it should be noted that the depth of it varies with the species and with the locality. Of some very mild corners it is said that bats may be seen there every month of the year.

Apart from a few North American species, which have three or four young ones at a time, ordinary bats are uniparous, and two is the limit. This is what we should expect, for an aerial mammal would be badly handicapped if the maternal burden were heavy. We refer not only to the ante-natal period (in North Europe from the end of March or beginning of April until June), but to the nursing time (from June until August), when the young bat clings with its toes and thumbs to its mother's hair and with its mouth to its mother's breast, the aerial flitting and wheeling,

glancing and doubling, going on as usual. When the mother rests she folds her wings round her child. The females live together in colonies apart from the males until late autumn, when the feminine society is dissolved for a brief space, the time of pairing. But the extraordinary fact is that although pairing occurs in the vigour of autumn, the internal fertilisation of the egg-cells does not take place till the following spring. Thus the disadvantage of having the young ones developing during a starvation period is evaded, and the carrying of the young before birth is reduced to a minimum. Nature's ways are wondrous wise.

Gilbert White had a tame bat which took flies from his hand. "The adroitness it showed in shearing off the wings, which were always rejected, was worthy of observation and pleased me much." Bell describes the playful ways of a Long-eared Bat which would fly up and gently remove a little piece of raw meat from between his lips. But there are probably few naturalists who have got on to terms of intimate acquaintanceship with bats. The fact is that most bats are timid, high-strung creatures, and that their brains are of a low order, not very amenable to cajoling. Moreover, many of them have a very disagreeable smell, and their interesting hair, with spirals or whorls of scale-like roughnesses, is apt to be somewhat too abundantly entomological. The Long-eared Bat seems to be free from both these reproaches, and has a pleasant way with it; but, on the whole, we must admit that the typical bat is not very approachable. But perhaps this should add to the fascination of "the busy, merry little harlequin of our English twilight," as Robinson calls the bat in his delightful *Poet's Beasts.* It is an epitome of quaintnesses and in its way a decided artistic success. It has suffered much from prejudiced and partial views. For why should we say "blind as a bat," when most of them have eager, acute little eyes? Why should one of the nimblest and busiest of creatures, that has to work hard for its dainty meals, be reproached as "lazy-lurking" and "torpid"? Why should a mammal that has solved the problem of flight in a way all its own and has reached a climax of tactile sensitive-

ness be libelled as an "ominous fowl" and a "dire imp of darkness"? The poets have a great deal to answer for.

On the ground bats are helpless, but many of them, the fruit-bat for instance, can scramble about quite quickly on the trees. The fruit-bat has very sharp claws on its toes, which it uses in climbing to grip the bark of the trees. With the sharp claw of its thumb it spears the fruits that are its food. This thumb-claw is all that remains of its hand as a hand, for the rest is taken up in the making of a wing. In the parachutists the plane is a mere extension of the skin of the sides of the body, but in the bat the wing, which can be freely moved and folded, is supported by bones. The fingers are enormously long, and so are the bones of the arm, and on them the thin skin-wing is spread out.

VII

MAMMALS OF THE MOUNTAINS

THERE are two great kinds of mountains—the original and the carved-out. Original mountains are due to the piling up of volcanic and other material on the earth's surface or to the crumpling of the crust. Fuji-Yama in Japan, Cotopaxi in Ecuador, Popocatepetl in Mexico, and the Peak of Teneriffe are well-known examples of volcanic mountains. But carved-out or relict mountains are the remaining portions of more or less elevated tracts that have been carved out unequally by frost and rain and other weathering agencies. Relict mountains are " monuments of erosion " ; they have been carved out of plateaux or great rock masses. This is very largely the case with the mountains of the Lake District in England and of the Highlands in Scotland. But a mountain is a mountain to its animal tenants, however it may have arisen. At the same time it must be noted that different kinds of rocks imply different kinds of vegetation, and this affects the animal population very intimately.

Every typical mountain shows three zones. Lowest there is the tree-covered zone, passing gradually into the forests and woods of the low country. Second, there are the treeless steppe tracts with varied herbage and often with good pasture on shelves and plateaux. One sees in Switzerland how the industrious peasants shift their cattle in summer to narrow shelves high up the mountains, where there is much better grazing than one would expect. Uppermost there are the relatively barren heights with " Alpine " plants of a hardy sort, and, finally, with nothing but lichens on the exposed rocks. Higher still there may be snow. When we take a survey of the tenants of the mountains we might well arrange them according to these three zones. Thus, there

are bears in the forest ; there are goats on the steppe tracts ; and there are marmots on the sparsely clad uppermost stretches. But we wish to suggest another grouping of the mountain animals, with special reference to the mammals and birds. (See Thomson's *Science Old and New*, 1924, p. 11.) We may recognise three groups : The *relicts*, the *insurgent colonists*, and the *refugees*.

During the time of the Ice Ages there was an extension of Northern or Arctic animals far southwards, *e.g.*, into Central Europe. We know this from their bones preserved in the floors of caves and the like. When the climate changed for the better and the glaciers retreated, some of the Northern animals died away ; others, like the reindeer, were able to trek northwards; but there were others that ascended the mountains. These may be represented by the little snow-vole, which very rarely descends below 4000 feet ; by the whistling marmot of the Alps, which used to be a tenant of low-lying steppe-land ; by the mountain or variable hare, which turns snow-like in winter; and by the ptarmigan, which shows the same seasonal change to winter whiteness. These and some others have found on the mountain heights the same sort of conditions as their ancestors found in the far north, or on the low ground at the foot of the glaciers when these crept far southwards.

The second contingent of mountain animals includes adventurous colonists from the low grounds that discovered the possibility of making a living at considerable heights. Sturdy animals are always on the look-out for new opportunities. It is partly, no doubt, because they tend to become too numerous, thus making it more difficult to get a living ; but there is probably in many cases something of the adventurous spirit. Hunger is a sharp spur, but many a higher animal has curiosity and an exploring turn of mind.

Among the insurgent colonists we include the chamois, which was probably, to begin with, an antelope of the Asiatic steppes. Along with the chamois must be ranked the goral of Indian altitudes, the Rocky Mountain goat,

the grunting yak of Tibet, the unlucky ibex of the Alps, the fine markhor of the Himalayas. And when the wild sheep and wild goats found pasturage by exploring to high shelves, they found safety, too. It was only for a time, however, for they were, of course, followed by insurgent carnivores; and so we understand the snow leopard and the mountain puma. In the same way we interpret the golden eagle as a colonist of the heights, following the grouse and the mountain hare.

The third set of mountain animals includes hard-pressed creatures which have sought for a way of escape from the too intense competition of the crowded low grounds. We cannot draw hard-and-fast lines, but they differ from the colonists inasmuch as they seek an asylum rather than a conquest. They suffer from some handicap. This is well illustrated by the coneys or hyraxes of Africa, Palestine, and Syria. They are small mammals, a "feeble folk"; they are not very quick nor very clever—wary rather than wise; they have little in the way of weapons or armour; they do not burrow. Some have saved themselves by becoming arboreal; the others by ascending the mountains even to 10,000 feet. They have thick coats "to keep out the cold"; their feet are well-suited for scrambling among the rocks. Similarly the desman of the Pyrenees, a small insectivore that used to occur in Britain, is a refugee on the heights. It has added to its safety by becoming aquatic, and it is also a burrower. It is a little creature, about five inches long in body and the same for the tail—a bundle of curiosities. Thus it has a very mobile snout, like the beginning of an elephant's trunk. Now if we understand the hyrax and the desman, we also understand the Alpine shrew, the Tibetan mole-shrew, the Himalayan swimming shrew, and others like them; all are refugees. Here also we should include such a bird as the water-ouzel or dipper, which is particularly fond of mountain streams.

Let us briefly illustrate how animals have become suited to the exposure, cold, scarcity, steepness, and other difficult conditions of the mountains. There is protection against the cold in having a thickset coat, such as we

see in a chamois, or dense plumage such as that of a ptarmigan. Turning white in winter, as in Mountain Hare and ptarmigan, lessens the loss of the precious animal heat, and may also hide the creature from its enemies. The ptarmigan has a stronger heart than its cousin the willow grouse

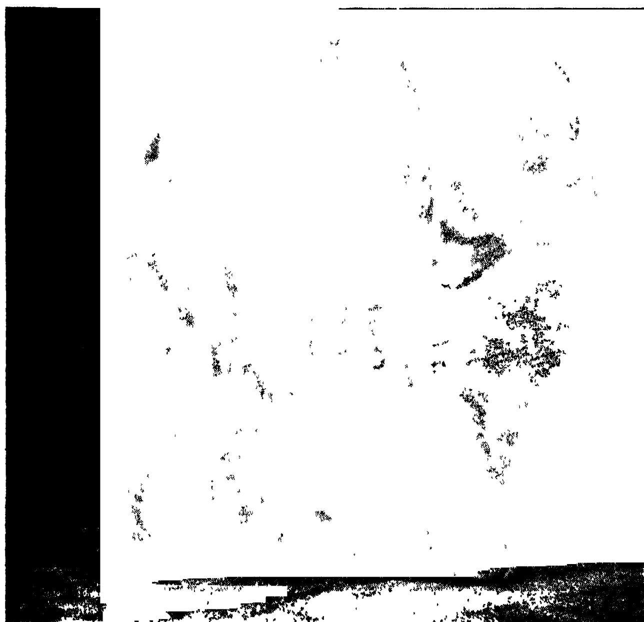


Photo: F. W Bond.

YOUNG PUMA.

In the Puma kitten the spots are well defined, thus illustrating the general law that the young stages of an animal's life-history come nearest to the ancestral type. It is delightful and playful in its youth, but it gradually becomes fierce.

that does not ascend high, and a strong heart is useful for mountain-climbers. In exposed places it is important to have a danger-signal, and we can hear this in the whistling marmot. It is often very valuable to have specially firm foothold among the rocks, and this is very well illustrated by the chamois and the hyrax. Another important adaptation is the ability to thrive on varied food, as bears do,

and at times on Spartan diet, as the Mountain Hare does when it eats the lichens off the rocks. (See Thomson's *Mountains and Moorland*, 1921.)

THE MOUNTAIN BEAVER

About a century ago there was discovered in Western North America a veritable living fossil, the Mountain Beaver (Aplodontia), which is regarded by some authorities as the only surviving representative of the group from which all living Rodents (gnawing mammals like beavers, squirrels, porcupines, voles, rats, mice, rabbits, and hares) have been evolved. In any case, there is no doubt that the Mountain Beaver is an antiquity—a survivor from very distant ages. It is restricted to the Pacific coast of North America between British Columbia to the north and California to the south—a short-tailed, blunt-snouted, " chunky " creature, rather over a foot in length, grey to black in colour, with small eyes and ears, and at the base of the ear-trumpet a white spot.

The Mountain Beavers are elusive nocturnal burrowers, not very well known. They require firm deep soil with abundant vegetation, preferring the banks of streams or damp hillside slopes where the water seeps down. In California they always choose a site covered with ferns, thimbleberry, and other low-growing plants which hide the openings of their extensive but shallow underground tunnels. There are cross-ways joining one tunnel to another, so that a network is formed ; and here and there comes a globular nest, lined with the leaves of fern and cow-parsnip. Beside a nest there is sometimes a low square room, with floor and sides showing signs of constant use. There are also pockets with stored roots, stems, and leaves, and these cupboards are sealed up with pellets of earth.

The habits of the American Mountain Beaver have been carefully studied by Mr. Charles L. Camp, of the University of California, to whose description we are much indebted for information about this retiring animal. It is a vegetarian with a varied bill of fare. It likes the root-stocks or rhizomes of ferns, the fleshy roots and succulent shoots of many plants,

the stems of sapling trees, and many kinds of grasses. It seeks its food at night and rests throughout the day. It is slow in its movements, cumbersome in its gait, and timid by temperament, so we can understand its gathering by night a lot of food which it afterwards consumes at leisure in the security of the burrow. Observers have often noticed an interesting " haymaking," parts of plants being neatly cut into lengths and laid out to dry. But this dried material seems to be used as a lining for the nest, and not as food.

There is no doubt, however, that pieces of sappy stem are laid by for hard times. The Mountain Beaver eats in a somewhat squirrel-like fashion, using its fore-paws or one of them to hold the food to the mouth. There is something rather striking in the fact that this primitive creature, an antediluvian, a sort of " living fossil," should have such good table manners. An interesting little detail is that it uses the short first finger as we use our thumb. Unlike a squirrel it sits back on its short tail when it is munching its food.

The Mountain Beavers sometimes ascend to heights of 6000 to 8000 feet, but they do not seem to hibernate like their distant cousins the marmots of the Alps. They have been seen hurrying rather awkwardly on the snow—they cannot hurry much ; and they actually climb on low bushes to get at sappy shoots. When a mammal can find food all the year round and can fall back on stores in the very worst times, it is not likely to be a hibernator. Mountain Beavers are very cleanly creatures, and the burrows are always well-drained. The refuse is probably buried.

How do these old-fashioned creatures hold their own ? Sight and hearing seem to be dull, but the Mountain Beaver is exquisitely sensitive to *touch*, as befits a burrower. " The slightest touch upon a hair will be responded to instantly by quick jerking movements." The sense of smell seems to be keen, and these shy but social creatures probably recognise one another by scent, for there are strongly developed odour-making glands. A curious feature—especially in a gregarious mammal—is the apparent absence of a voice, but an alarm note is produced by rasping the lower front

teeth (incisors) across the tips of the upper ones. The same sort of dental sound is made by some other Rodents, such as the North American pocket-gophers and marmots, and we may hear it from the common hare.

Almost nothing is known about family affairs, but there are probably two litters in the year, with four to six young ones in each. We have already mentioned the safe and comfortable nest.

It is important to understand the *meaning* of this strange life. Here we have a slow-going mammal which a child can catch, a rather dull creature, too clumsy in its movements to fight effectively when attacked, an animal of a timid temperament and a far from hardy constitution! What better could such a creature do than take refuge on the mountains and in their underworld? As a burrower it is at home, able to move head foremost or tail foremost, with small eyes and ears and a short tail, none of them the least in the way. Its touchiness helps it in its nocturnal foraging, and there is a note of perfection in the white sticky tears, for they may lessen the risk of the eyes being scratched in the burrowing. So the Mountain Beaver still holds its own, in spite of skunks and wild cats, eagles and horned owls.

On a Scottish high moor, mostly snow-covered, one may sometimes have the luck to see at the same time two white animals—the Mountain Hare and the Ermine. The first is snow-white, all but the black tips of its ears; the second is snow-white, all but the black tip of its tail. It is not altogether a fortuitous coincidence that the two white mammals are sometimes seen at the same time, for the ermine often meditates an attack on the hare. But this raises again a problem, already hinted at. The winter whiteness of the mountain hare certainly gives it inconspicuousness against the snow, so this will conceal it from the hungry eyes of its enemies. But the ermine, which is the chestnut-brown stoat in summer, is also concealed in the same way, which will make it easier for it to get near the hare.

MOUNTAIN HARES

When Thomas Pennant made his tour in the Scottish Highlands in the autumn of 1769, he saw "white hares," as he called them, on the mountains, and wrote to Gilbert White about them. In the answer from Selborne there is the interesting sentence: "It pleases me to find that white hares are so frequent on the Scottish mountains, and especially as you inform me that it is a distinct species; for the quadrupeds of Britain are so few that every new species is a great acquisition." These white hares continue to hold their own, and in some parts of the Highlands they are actually plentiful, as the windows of the game-dealers' shops plainly testify. They have been introduced here and there in England and Wales.

Compared with the Brown Hare, the Mountain Hare is smaller, more rabbit-like, with larger head, fuller eyes, shorter ears, relatively longer hind-legs, and softer pelage. It is not so quick on its feet though very swift compared with most mammals, and it is not so alert or "timid," perhaps because it is less accustomed to enemies, perhaps because it is a much less intelligent animal. Another difference is that instead of having a "form" among the grass, the Mountain Hare hides in clefts of the rocks or among stones; and on rare occasions it may even excavate a hole in the ground which some would count as a burrow. It is able to live on food much coarser than the Brown Hare will touch, unless indeed the worst comes to the worst. Thus the White Hare will eat heather-tips in the winter and nibble the lichens off the rocks. Little wonder then that the flesh is less palatable, though that varies greatly with the locality, and little wonder that its price in the shops is much less.

The Mountain Hare begins to change its dusky brown upper colour in September. Towards mid-winter it is quite white, except the black ear-tips. Like most rodents, it is always shedding hairs, and those that are replaced in the autumn are more or less unprovided with pigment. They are, therefore, white; that is to say, they reflect all the rays

of light, especially when they are massed together in the fur with intervening air spaces. But this is not the whole story, for individual brown hairs in the pelage or fur may change into white ones, as Professor MacGillivray, of Aberdeen, showed long ago. How is this transformation effected? The answer is largely due to the illustrious zoologist and physiologist Metchnikoff, who showed that wandering amœboid cells from the core of the hair pass into the outer layers, engulf the microscopic granules of brownish pigment, and carry them away, passing through the base into the skin. Soon afterwards the hair becomes a dead structure, in its exposed parts at least. The same phenomenon occurs, according to Metchnikoff, in the winter-whitening of the ptarmigan's plumage and when man's hair becomes grey. He called the wandering cells chromophages, which means colour-eaters.

We remain personally of the old opinion, which we express with caution because our observations have not been extensive, that the whiteness is partly due to the presence of minute bubbles of gas, and not wholly to the absence of pigment.

We have watched a White Hare hirpling over a snow-covered moor, and stopping to look at us inquisitively. When we gave chase it disappeared like a wraith. The first thought, if it is not the last one, is that this creature is well hidden when on a background of snow. It has the secret of the Gyges ring: it makes itself invisible. There are good reasons, however, for not pressing this interpretation. When the White Hare is *not* on a background of snow, and that is often, its whiteness makes it very conspicuous. It must be remembered, moreover, that when there is much snow on the hills and uplands the White Hare tends to seek lower elevations and more sheltered places, where its whiteness is almost like an advertisement.

The chief meaning of the whiteness must be sought, we think, in another direction. It is primarily due to the fact that in autumn the conditions of hair-development on the upper parts of the body are different from those that are operative at other seasons. This does not mean that the

animal is out of condition, for the reverse is the case in autumn; moreover, the fur of the underparts is always white. Secondly, this physiological rhythm has been fixed by ages of natural selection, not so much because the white coat is sometimes a cloak of invisibility, though that may have considerable value among animals that live in Arctic regions, but because it is the coat that loses least of the precious animal heat of the body.

The males and females live more or less apart in the winter, but very early in the year the buck scents out the spoor of the doe. He is a free lover, and rivals often fight, standing up on their hind-legs and boxing, or biting at one another with their chisel-edged front teeth.

VIII

MAMMALS OF DESERTS AND PLAINS

WE cannot think of the desert without thinking of the camel, which is certainly one of its most characteristic tenants. One of its conquerors we may say, for the fitnesses of the camel to desert life are many. Long limbs and freely-moving thighs make for speed—150 miles a day for four days on end, and ten miles an hour when the camel pleases. The hoofs are reduced to nail-like structures, and the two digits (numbers three and four), which lie very flat on the ground, are supported by cushion-like pads, suited for shuffling over the desert. Moreover, the lower end of the cannon-bones (the fusions of the two palm bones in the fore-limb and of the two instep bones in the hind-limb) diverges into two knobs which have lost the usual keels that restrict sideways movements of the digits. Thus it is that the two toes yield and spread out in a splay-footed fashion, thereby tending to keep the heavy animal from sinking deeply into the sand.

The camel has two humps, the dromedary has one, consisting of gelatinous fat, and this means a reserve for a desert journey. In evil days the quaint excrescence sinks down flaccidly on one side, the camel being most dejected when it shows least hump! Also noteworthy are the water-reservoirs in the wall of the paunch, about 800 little flasks with a closing muscle round the mouth of each. They are filled automatically when the camel slakes its thirst or when there is fluid sap in the paunch. "In time of water scarcity," Professor Lull writes, "the stored liquid is allowed to trickle out into the stomach and is thence available for the impoverished blood." Here it may be mentioned that while camels chew the cud they resemble the old-fashioned chevrotains or deerlets in having only three chambers in their "stomach"

instead of the usual four. The ordinary third chamber, the "manyplies" of sheep and cattle, is only hinted at. Perhaps it is beginning, or is it disappearing? The cheek-teeth are well suited for grinding the rough herbage, which forms a large part of the camel's diet.

The head is carried high, and thus the eyes are removed from the ground-reflected heat; the lashes are long and keep out dust; the ears are stopped with hair, and the nostrils can be closed against the driven sand; the camel is long-sighted, and it scents water from afar. In short, there are many ways in which the camel has answered back adaptively to desert conditions. And besides details like the tough skin and the callosities on the knees and chest, there is the general virtue of endurance. Thus we read of a hundred well-loaded camels journeying for thirteen consecutive days with absolutely no fresh water. Professor J. W. Gregory cites a case from Australia, where some of the naturalised camels were marched 537 miles in thirty-four days without watering. One must not, of course, make a miracle of such instances, for camels get fluid by picking up plants as they journey.

The consequence of the camel's fitness, and likewise of its usefulness both living and dead, was that man made it his slave. Those that were too rebellious or cantankerous were eliminated; all work and no play made the camel a dulled beast of burden. No doubt some of them occasionally mutiny and run away, like the "wild" herd in Spain. No doubt they protest continually, grumbling and growling, biting and kicking. Perhaps, as Mr. Henty says, they have cultivated ill-temper until it has become a form of enjoyment. It almost seems as if they had formed a sort of Camel Union, one article in the constitution being that no transport camel's pace shall ever exceed two and three-quarter miles an hour; and another that if man will ride on them he shall know how "the ship of the desert" can roll. It does not appear to be true that the last straw breaks the camel's back, for if the burden is too heavy the camel will not even attempt to rise. But the sad admission must be made that man has engendered in the camel an obstinate "dour-

ness." Man gives it no affection, and this is reciprocated. No artist would call a camel ugly, but it gazes at the world with a bored contempt, with a "sculptured sneer." On the other hand, as it ruminates, it sometimes seems as if it were preoccupied with some precious thought, such as that Camelidæ are the only mammals with elliptical red blood corpuscles. Camels are aristocrats in chains.

Uncertainties still obscure the story of the domestication of the camel and the dromedary. We do not know the where or the when. The two kinds will inter-breed, the mule having the single hump of the dromedary and the brown, shaggy coat of the Bactrian camel; but a separate origin from two wild species is practically certain. The camel probably arose more to the North, between the desert of Gobi and the plateau of Iran. The dromedary's headquarters were probably in Arabia and North Africa. Both have had a long servitude, but, perhaps, for the beasts, that is better than extinction. There are certainly no wild dromedaries nowadays and it is very doubtful if there are any wild camels. There are the famous herds of Lob-nor and Turkestan, but it is very likely that these should be called "feral," which means escaping from domestication into wildness.

The race of camels began in North America millions of years ago, in the Upper Eocene Age. It began with a little creature called Protylopus. It was no larger than a jack-rabbit and had four digits, but Nature waved her wand and said: I shall make a big thing out of you. So, as millions of years dragged their length along, there arose in the Oligocene another pioneer camel, Poëbrotherium, which attained to the stature of a sheep and had almost quite lost the second and fifth digits on each limb. In the Miocene came the two-toed Procamelus, rather bigger than the modern llama, which is the camel's second cousin. The Pliocene saw the advent of Pliauchenia, and in the Pleistocene there were herds of camels which trekked across the Behring Strait bridge to Europe, leaving North America with no living representatives, but with a glorious graveyard of camel-like progenitors. And yet some people in America

have the effrontery to say that they do not believe in evolution!

Though the dry steppe has nothing to compare in richness of individuals with more grassy plains, it has interesting ungulates that are all its own. The odd-looking Saiga antelope roams in thousands over the steppe. It is about the size of a fallow-deer, with short legs, a yellowish coat that turns much paler in winter, and lyrate horns in the male. Its most peculiar feature is a greatly elongated and swollen nose with very wide nostrils set far apart. Though it resembles other antelopes and gazelles in its general characters and habits, it has an " ovine expression " and its fleece, too, is sheep-like. In common with all the large animals of the steppes, where concealment is scarce and famine or drought comes suddenly, it has great swiftness. But it lacks staying power and the Kirghiz horsemen can often run it down.

The Bactrian or two-humped camel with shaggy hair, hard feet, and short legs, is very characteristic of the steppes. It is a highly valued domestic animal among the nomad tribes, but it is a disputed point whether the wild herds that undoubtedly exist are really wild, or only feral like the well-known herd in Spain. It is suggested that so many human settlements and even cities have been destroyed by hurricanes or sand-storms that the " wild " herds may really be descendants of camels that belonged to the inhabitants of these. However that may be, they are well adapted to steppe life, for unlike the Arabian camel, they walk easily on hilly or rocky ground; they can endure great cold; they are satisfied with the salt herbage, if nothing better can be got; they drink freely of brackish water; and the two humps enable them to store up fat for times of scarcity.

Among the most interesting, and certainly the most attractive, of the ungulates of the Asiatic steppes are the wild horses and asses. There are at least three kinds, the tarpan or wild horse, Przevalsky's horse, which shows most affinity to the domesticated form, and the kiang or wild ass which chiefly frequents the high plateaux of Tibet. All three have similar habits. During summer they wander about in small troops of ten or fifteen mares with their young ones,

each troop led by a single powerful stallion. All other males are driven out of the herd as they approach maturity, and they wander about singly till they have come to their full strength. Then a solitary stallion will stand for hours at a time on a hillock, on the look-out for a troop. When one appears he rushes to meet it, challenging its leader, who is never slow to defend his rights. The battle between the two stallions is fierce and may be long, but the rest of the herd look passively on. If the intruder is victor they immediately follow him and he rules them as despotically as did their vanquished leader. Strength and alertness are as necessary to the wild horses as swiftness, for there is no cover for animals so large, yet the shrubby thickets may conceal the slinking wolf. But a stallion strong enough to gain and keep a troop of mares is a match for any wolf, and even for more than one. It is only the laggards and the weaklings that are apt to fall a prey, and even these not very often in normal circumstances, for the acute senses of the horses give them early warning of the enemy's nearness.

Human enemies are more difficult to evade, and hunting wild horses has long been a favourite sport with the nomads. The wild horse has been described as a proud, fascinating creature, full of dignity, strength, and high spirits, shy, but almost coquettish in its bearing. When pursued they stare curiously for a while, then take to flight. A troop retreats in orderly line, stops, faces round, turns again, and resumes its swift flight with beautiful precision at the leader's command. They hardly need to use their utmost speed, and may often be seen holding themselves in for the sake of the foals, and they are only run down when they are surrounded with horsemen in a wide circle.

"The time of blossoming is short and the time of withering and dying is long in the steppes." Springtime, with its rainfall and its melting snow, is the only season of real plenty. The hot dry summer comes all too soon, and everything is withered up. Autumn brings some improvement, for a little ; there are seeds and fruits and withering grasses, and the wild horses are easily contented. But when frost comes and the pools and lakes are coated with ice, they are

hard put to it for water. Troop joins troop till a great army is formed, and they wander, not towards the warmer south, but northwards to regions of deeper snow, where they may satisfy their thirst, and find sufficient food by scraping away the snow with their hoofs. Winter at the best is a time of scarcity and hardship, and the whole herd becomes thin and starved looking. They can endure great cold, but should a slight thaw set in, followed by frost, they are unable to break the surface-cake of ice over the snow and many perish miserably. This is the wolf's opportunity. But the plucky little creatures are very elastic; those that survive soon recover their high spirits, and, at the first hint of brighter days, they gallop joyously back to their summer pastures, where they break up into little troops as before.

IX

AQUATIC MAMMALS

THE first backboned animals to get a footing on dry land were certain Amphibians, and this happened in Devonian and Carboniferous ages. From ancient Amphibians there sprang Reptiles; and from terrestrial Reptiles there evolved Birds and Mammals. But, as may be readily understood, life on exposed dry land was not easy, and many terrestrial animals sought out other haunts promising some relief from the keenness of the struggle for existence. Thus some became tree-animals and others became burrowers; some became flying animals and others returned to the sea. We take porpoises as good examples of the descendants of land mammals that harked back to the ancestral aquatic habits.

The distinguished physiologist, Professor Sir John Burdon Sanderson, once remarked that our delight in looking at a beautiful animal is often mingled with an admiration of its *fitness* for its particular habitats and habits. This wise remark applies well to porpoises and dolphins. Their swimming movements are harmonious and beautiful in themselves, and the curves of their body are very pleasing, but when we watch them or any other Cetaceans (whale-like mammals) we are unconsciously influenced by the fact that they are big bundles of fitnesses.

The shape of the body is admirably fit for rapidly cleaving the water; the lines of the body are stream-lines like those of a yacht. Everything is done to reduce friction; the skin is smooth, and there are no protruding structures like ear-trumpets. The tail is flattened horizontally, and turned into a propeller that shifts the water first to one side and then to the other, but a propeller that does not go round! The fore-limbs have become balancing flippers. Almost all trace of

hair has gone, but its place in retaining the precious animal heat is taken by the thick layer of non-conducting blubber, which also makes the Cetacean more buoyant. And when we ask what blubber is, we find that it is simply an exaggeration of the layer of fat (the *panniculus adiposus*) which is found in almost all mammals, the common hare being a familiar exception. The nostrils, united in a single blowhole in toothed Cetaceans, are situated on the top of the head, and this helps breathing (inspiration and expiration) when the animal comes to the surface. Moreover, the nostrils are valved, so that water does not enter when the creature is submerged.

The reduction of the neck to an extreme of shortness is well suited for diving full fathom five and more. There are strange networks of blood vessels, which are believed by some to allow of the storing of oxygenated blood before a prolonged stay under water. There are arrangements for giving the young one a large drink of milk all at once, for suckling must be a little difficult out at sea. There is also an interesting way of shunting the larynx (at the top of the windpipe) forwards till it meets the posterior openings of the nasal passages, so that a continuous passage is formed from the external nostrils to the lungs. Therefore, when the mouth is open, in dealing with a struggling fish, for instance, the water does not go down the windpipe.

THE PORPOISE

Porpoises are the commonest of British Cetaceans and many people are familiar with their gambolling in the waves. The movements are very graceful, and when a number swim together in a line with the crests of their backs showing at regular intervals above the surface, one gets a very presentable sea-serpent! Every half-minute or so, when it is hunting for food, the po poise shows at the surface. First the snout and head are seen, then the middle of the back and the dorsal fin, finally the tail-flukes. In half a minute the snout appears again. The whole of the energy comes from the twisting thrusts of the propeller; the

flippers are for balancing and sometimes for suddenly putting on a brake. Their normal position is pressed close to the sides of the body. What we have just said about movements is not warm enough, for there is a delightful " go " about them when the members of a school indulge in games, as they often do. On such occasions there are often leaps and gambols, somewhat more adventurous than the ordinary rhythmic roll.

The porpoise ranges from the Mediterranean across the Atlantic, but it is commonest not very far from the coasts. It is a very familiar animal in fiords and firths like the Firth of Clyde, familiar to the ear as well as to the eye, for who does not know the sound, between a sob and a sigh, which tells one in the dusk that a porpoise has just given out a great breath of air. There is no carrying up of water in a blast as in the larger Cetaceans.

For the most part the porpoise is a fish-eater, and levies toll especially on open-sea fishes like herring and mackerel. Where the mackerel abound there are the porpoises gathered together, sometimes in schools of half a hundred. At other times they may prowl about close inshore, searching for codlings and the like, and their partiality for salmon leads them sometimes far up the rivers. They are often seen above London Bridge, and there is a record of one having been caught at Paris. The teeth are well suited for fish-catching, but they are not sharp-pointed cones as in true dolphins; they have rather spade-like crowns. They number twenty-six above and below.

With very few exceptions a single young one is born at a time, which may be in part an adaptation to the difficulty of suckling in water, and in part an indication that the security of the porpoise's tenure of life has been sufficient to allow of greatly economised multiplication—small families, in short. As is common in highly endowed mammals, there is a long period of development before birth, for the mother carries the young for about ten months before it is born. There is strong maternal affection and prolonged carefulness. In his great book on *British Mammals*, Millais tells of the capture of one of two por-

poises that were swimming beside the boat. The captive was not killed, simply kept on board, and the other one continued swimming alongside for over half an hour. The captive was then returned to the water, and the two went off together. It is not certain that the captive was the offspring and the loyal companion the mother, but that is probable. If not, the observation illustrates a strong development of kin-sympathy.

It should be noted that the mother-porpoise, like all other Cetaceans, brings forth its young one in the open sea, in marked contrast to the seals, which have to return to the land to calve. Similarly, while the young porpoise swims right away, the young seal has to be nurtured for a considerable time on shore. Indeed, if the very young seal tumbled into the water it would drown. The contrast indicates, of course, that porpoises and their relatives have been much longer in the sea than the seals have. This is borne out in other ways, for instance, by the absence of any external trace of hind limbs in Cetaceans, whereas in seals they are well developed though no longer of use as organs of support. Both porpoises and seals are aquatic descendants of terrestrial mammals, but the ancestors of seals were land carnivores, whereas the pedigree of the porpoise is unknown. Both illustrate the widespread tendency to seek out new kingdoms to conquer, new niches of opportunity to fill.

So far as we know, it has not been the good fortune of any naturalist to establish an intimate acquaintanceship with a porpoise, and little is certain in regard to the creature's inner life. It is a sociable, brainy, playful, affectionate animal, that has made a success of its life. It is said to have a voice, but we have never heard it.

WHALES IN GENERAL

Whales are very interesting in their structure and habits, especially in their manifold fitness for entirely aquatic life. But their interest is greatly increased when we study them in the light of their history—when we understand that they

are the descendants of mammals that have returned to the sea after being for a long time at home on dry land, just as Loggerhead Turtles that live far out to sea are derived from ancestral terrestrial tortoises. Let us think of whales in the light of their history.

Deeply buried in the whale's flesh there are small vestiges of the hip-girdle and the hind legs. Of these dwindled pieces of skeleton it is safe to say that they are of no use. They are often called *rudimentary* organs, but it must be clearly understood that they are not beginnings of structures that might in the course of time become large and effective ; they are dwindling, vanishing relics. It is extraordinary to find in a thirty-foot whale a piece of bone which corresponds to the thigh, and yet is not as long as our hand. What a contrast to the thigh-bone of the extinct reptile Atlantosaurus, which is six feet in length ! But what is a whale doing with hind legs buried deep below the surface and useless ? The only answer is that they are the dwindling relics of hind legs that were large and of use in the terrestrial ancestors. The whale's tail has become a *non-rotating* propeller, with the flukes as blades. In a seal, which is a Carnivore, not a Cetacean, the hind legs are not of use for standing on, and yet they are not vestiges. We see why this should be when we notice that they are turned backwards to form the chief propelling structures. They lie beside the short stumpy tail, which is not broadened into flukes like the whale's. In both cases, it may be noted in passing, a mass of water is displaced first on the one side of the hind end of the body, and then on the other side, in rapid alternation. The blades of the propeller are the flukes in the whale and the hind-legs in the seal, but it is a *sculling* mode of locomotion.

Whales are practically hairless ; they are covered with smooth slippery skin, well-suited for reducing friction in swimming. This is obviously very unlike a mammal, for the typical mammal is hair-covered. But the accepted fact that whales are transformed terrestrial mammals throws light on the abundant rudimentary hairs on many *unborn* whales. The past lives on. We also understand

better the persistence of a few sensitive hairs about the lips of many a whale. It is surely an eloquent fact that a cetacean sometimes keeps just a few of its hairs in a strategic place, where they are of use as touch-structures, just like the whisker-hairs (or vibrissæ) on a cat's cheeks. Those touch-hairs of the whale's lip are often very richly supplied with nerve-endings (sometimes 400 nerve fibres to a single hair !), so that although they are remnants, they are far from being useless relics. But our point is simply this, that the whale's little moustache shines out when we turn on the light of evolution.

A whalebone-whale or baleen-whale has no teeth in adult life. It rushes agape through the water and catches myriads of sea-butterflies (open-sea Gastropods) and other small fry on the frayed edges of the horny plates which grow down from the palate into the cavity of the mouth—sometimes to a length of seven feet ! Every now and then the whale raises its tongue and swishes its multitudinous booty of jujube-like creatures into its gullet. It does not need teeth, and yet the remarkable fact is that it has two sets of them. But they never cut the gum ; they are absorbed before birth. What a conundrum these two sets of useless teeth would be unless we knew that they are relics from past ages when the ancestors of whales lived on land and chewed their food.

We were at anchor late one summer evening in a fiord, where the stillness was complete. There were no breaking waves, no crying birds, and even the ship itself was as quiet as a mouse. All of a sudden just beside us a biggish whale spouted—there was an explosive burst as if of steam, and we dimly saw a pillar of breath and spray rising in the air. What is the whale's spouting in the light of history ? The whale is a mammal, not a fish ; it must therefore breathe dry air, it cannot in fish fashion make any use of the air that is mixed with the water. The toothed whales have to pursue their food in the depths. It is therefore advantageous that the acts of breathing should be reduced in number, since they must occur at the surface. The " blowing " is the forceful breathing-out of used air, and there are often several

spouts in rapid succession. Then follow deep in-breathings, and the whale can store large quantities of air in its lungs (perhaps also in its blood) so that it can remain submerged for ten to twenty minutes. The spout consists mostly of the out-breathed air, plus water-vapour that may condense into drops in the cold, plus perhaps a little sea-water carried up. It may rise to a height of fifteen feet. These, then, are a few examples of the way in which the new Natural History looks at living creatures in the light of their history. Everything is an antiquity. The hand of the past is on the present—a living hand.

SEALS

While dolphins, porpoises, and whales or Cetaceans generally, are rightly ranked among the conquerors of the Open Sea, the seals are to be thought of in connection with islands and the seashore. They have not attained to the Cetacean's independence of dry land.

There is no doubt that seals are the descendants of terrestrial carnivores that took to a seafaring life. They betray their land origin in coming ashore to rest and sleep and to bring forth their young; but the great adventure of becoming marine must have been made long ages ago, for there are many aquatic adaptations in the seal's body. The somewhat conical shape is suited for swift movements in the water; there is reduction of friction in the absence of ear-trumpets, in the close-set fur, and in the way the hind-legs are thrown back beside the short tail. The nostrils can be closed under water; the sensitive whisker hairs are of use in the dark diving; the structure of the eye is also suited for the gloom in deep zones. The blubber beneath the skin makes the seal more buoyant; it helps to conserve the precious animal heat; and it is a store of reserve material for days when it is too stormy to fish. The teeth, with their tips tilted backwards, serve to grip the slippery booty. Both hands and feet are webbed, and clawed as well. No doubt the seal is a bundle of fitnesses.

The Common Seal and the Grey Seal may be called residents on British shores, and there are four others which

are known as visitors. The Common Seal may go far up a river and even reach an inland lake ; thus it has been seen at Perth and in Loch Awe.

The Common Seal can swim at the rate of ten miles an hour, about half as quickly as a dolphin, and the instantaneousness of its turning is like magic. A fish—like flounder, or whiting, or salmon—has no chance when a seal has made up its mind. When we watch a dog swimming we see that it treads the water with its fore and hind limbs ; but this is not the seal's method. It keeps its fore-limbs close to its breast, except when turning or steering, and it swims like a fish by means of its very muscular posterior body, aided by the firmly appressed legs, which form the hind part of the propeller, dislodging masses of water first to one side and then to another, with lightning-like quickness. The large Grey Seal is not nearly so fast, and it has, therefore, to attend to more slowly moving fishes, like halibut, which it seeks out far below "full fathom five."

The movements of seals on the sand are very quaint. They hirple along at the rate of about three miles an hour. The creature raises its shoulders, depresses its head, sticks its fore-flippers outwards in the sand, drags its body forward (sometimes helped by a jerk from the hind-legs), sinks prone, and begins again. What catches the eye is the alternate arching and flattening of the body. A young grey seal has been known to make a land journey of half a mile to a cottage, and when it was taken back to the sea it repeated the visit next day. Short land journeys have often been recorded for the Common Seal, especially in the case of tame ones, which refuse to be sent back to the sea. There seems to be in seals something of the "local attachment" and "homing capacity" which is exhibited by cats, but most of the data remain unfortunately at the level of anecdotes. Common Seals have their favourite resting rocks, and the Grey Seal has favourite spots in the water, where it persists for hours and days.

The Common Seal is still common. It has made a success of life along the coasts of the North Atlantic and the North Pacific. It is more Scotch than English, and there are

quiet places where one can see a hundred in a day. Of late large numbers have appeared in the Wash. When we go a-fishing in the evening on one of the western sea-lochs, the seals come about companionably, raising their bullet heads above the surface, and staring at us with their large liquid eyes. They are very quick of hearing, and will gather to an unusual sound. It seems to be rather from curiosity, however, than from a love of music, for they will come to a concertina as well as to a flute ; and when they have become accustomed to the sounds they cease to be interested. It may be, however, that this only means that they wish a change of tune. Indeed, we are inclined to be generous, for seals have fine brains, and their undoubted capacity for becoming attached to persons and places shows that the emotional string is well developed. This is seen also in their playfulness, in their "follow-my-leader" games, in the lovingness of the mothers, and, perhaps, in the way they kiss one another.

Common Seals are at once polygamous and polyandrous, so the less we say about their mating relations the better. September is the breeding time, and four or five months before that the sexes have been living for the most part separately. The mothers have their pups in June, after carrying them in the womb for nine months. They suckle them for about eight weeks. The males do a good deal of fighting in the latter part of August.

Whereas dolphins and other Cetaceans bring forth their young in the water, the seals, which are more recent colonists of the sea, bring forth their young on land. The young of the Common Seal sheds its first coat of (white) hair before it is born ; it begins its independent life with its *second* coat, which is darkish. The pup can take to the water the day of its birth, but it needs long rests ashore and much mothering, which it certainly gets.

The Common Seal has no enemy save man and its own big cousin—the Grey Seal. Unlike the dolphins and porpoises, the seals must have their rest on land. They take advantage of waves to get up on a rocky shelf ; they use their nails in clambering ; they adjust themselves so

as to slip into the sea in an instant; they sometimes post sentinels; but they often fall asleep. And it is then, and at the breeding time, that man often clubs them. It is a strange inconsistency that although man cannot deny that seals have a certain fascination for him, he cannot resist killing them when he gets a chance. He calls them lost souls and fallen angels, mermaids and mermen; he has invented pretty stories about them and cherished superstitions; but he kills them at their play and in their sleep, or when the mother comes ashore to comfort her young. We can hear the seal's melancholy cry!

SEA-COWS

On the Atlantic shores of Africa and America (as far north as Florida) there live very strange, old-fashioned mammals, called Manatees. Black in colour, thick-skinned, with flipper-like fore limbs and no hind limbs, they are bundles of peculiarities. Thus the upper lip is split into two, and the bristly halves play on one another like the points of a pair of forceps. With these they grip seaweeds, along with which there is often swallowed a good deal of sand. The Manatees sometimes go up rivers, and then they feed on fresh-water plants, like water-lilies. There are numerous back teeth for milling the tough and gritty food, and as these get worn away, their place is taken by others.

Related to the Manatee is the Dugong of the Indian Ocean and Australian Seas, the only other living "sea-cow" (or Sirenian). It is the basis of *some* of the mermaid stories, for the young one is held to the breast with one of the flippers. But this would not explain European "mermaids," would it? The dugong is a seaweed-eater, but its back teeth are few in number and soon fall out. They are not of much importance in chewing, and their place is taken by horny plates.

There used to be a third member of this strange old-fashioned order, namely Steller's Sea-Cow, which frequented the Behring Strait. The last one was seen in 1854, for the

interesting creature was exterminated by sailors. It was much bigger than its living relatives, for it reached a length of twenty to thirty feet; but it also was a seaweed-eater. There were no teeth at all except two vestiges on the upper jaw, but there was a very strong horny palate against which the seaweeds were rubbed to shreds. It is interesting to see in these three nearly related animals three different ways of eating seaweeds.

X

ROVING MAMMALS

THERE are several kinds of mass-movements among animals, and the name Migration is often loosely applied to any of them. The word migration does not really mean more than passing from one place or country to another, but it has come to be applied to a particular kind of mass-movement, and it will make for clearness to keep it strictly to that sense. Migration in the strict sense is that seasonal change from summer quarters, where the young are born and brought up, to winter quarters, where adults and young alike feed and rest in preparation for the journey back to the breeding-grounds, and the strenuous labours that await them there. True migration is therefore bound up with weather, with food supply, and, perhaps mainly, with the birth of the young. In this sense it is best illustrated among birds, but many other creatures migrate regularly every year.

MIGRATORY SEALS

The fur seals of the Northern Pacific spend almost two-thirds of the year in the open sea, the large males, or bulls, keeping apart from the troops of females and young immature males. They follow the fishes, and still more the cuttlefishes or squids, which form their favourite food. They may be seen far out at sea tumbling and playing on the surface of the water, just as dolphins do, and during all that time they never come near the land. When spring comes, however, they set out for their breeding-places, and " many of them travel steadily across more than two thousand miles of the North Pacific. For days at a time they swim through a roaring, gale-swept sea, under dense,

low-hanging clouds, and with unerring certainty strike certain passages in the Aleutian Islands, through which they travel to their breeding-grounds, more than a hundred miles beyond, on the small fog-hidden Pribilof Islands."

Early in May the bulls begin to arrive at the shores of the islands. The bulls are large, fat, and in splendid condition, and they land on the beaches, where each chooses out a special territory several yards square for himself, and prepares to defend it against all comers. The favourite sites are those nearest the water, and these usually fall to the largest and strongest bulls. A great deal of fighting goes on, and no bull leaves his territory for a moment, so that for many weeks they neither eat nor drink, and they get very little chance to sleep!

The gentle cow-seals, which are only about a fifth of the size of their partners, arrive about a month later. They get rather a rough welcome, for each bull wants to get as many cows for himself as he can, and though he proceeds by coaxing and enticing, there is such constant quarrelling with other males that the females do not have a very peaceful time either. Even when one is quietly settled down, a neighbouring bull may seize her and carry her off by the scruff of the neck to his own ground, while her original lord and master is engaged in trying to coax another new-comer to join his household. The seals remain on the islands for at least four months. After the first few weeks the cows go regularly to the water to fish, and as the fishes they like become scarce about the coasts they have to make longer and longer excursions. The young seals, too, go down to the sea in swarms to play and to learn to swim and catch fish, but each mother can invariably pick out her own calf from many hundreds, and she repulses all others.

Towards autumn the great colony begins to break up, the big bulls being the first to go. As it is only during the three or four weeks just before leaving, if even then, that they have had any food or rest, they are thin, exhausted, and not nearly so pugnacious as when they arrived. But they soon pick up again in the quieter conditions, and with the abundant food of the open sea.

During mild winters it is said that the seals never go very far from the shores of their island home, for the place where an animal brings forth its young is its true home, and is often, though not always, the original home of its race. But in severer winters the cows and young males may go as far south as off the shores of California, though the bulls usually remain about the coasts of Alaska.

WANDERING MAMMALS

Let us turn now to movements which are not migratory in the strict sense, because they have no direct connection with breeding. They may be called periodic wanderings. These may be due to conditions of weather, or of food-supply, or both, for the food-supply is often dependent on the season. Thus shoals of herring and mackerel are continually moving about from one part of the sea to another, following in the wake of the small animals on which they feed, and they are followed by larger fishes and other animals, which prey upon them in their turn.

Mr. Lockwood Kipling tells us that when the figs in the groves round the temples in India are ripe, the monkeys come forth in troops from the jungle to feast upon them. The figs have indeed been planted for the monkeys, which are held sacred in India, but unfortunately they do not confine themselves to the fruit intended for them, but rob every field and garden on their way. And in South America we are told, " whenever the golden orange glows among the dark foliage of the plantations, the capuchin monkey makes its appearance to share the fruit with the owners."

On the steppes and uplands of Asia, the wild ass lives a free and joyous life. " The range of the mountains is his pasture, and he searcheth out every green thing." The asses form small troops, consisting of a male, several females, and some foals. Like the domestic ass, they are easily satisfied in the matter of food, and live quite happily on dry and rather salt herbage. But when winter comes, even that begins to fail them, and troop joins troop till a vast army is formed, and they begin to march *northward*. It is not warmth they are

in search of, but snow, for wherever the ground is covered they can get grass enough for their needs by scraping the snow away with their hoofs. But when a thaw melts the surface of the snow, and is succeeded by a frost severe enough to turn it into a cake of solid ice, the wild asses are in sore straits and many of them perish.

In southern countries, such as South Africa, it is the long dry season which makes life difficult for grass-eating animals. It is then that antelopes, gazelles, and all sorts of herbivores stampede in thousands from the thirsty land.

LEMMINGS

All over the northern parts of Europe, Asia, and America lemmings are abundant at all times. There are several species of them, but, with the exception of the Banded Lemming of North America, which alone turns white in winter, they are so like each other that they may all be taken together. They are very like many of the common field mice in appearance, but are larger and rather dumpy-looking, their tails are shorter, and the hair on their backs is very long. They are brownish in colour on the whole, but they vary greatly. They keep chiefly to the opener parts of their region, and live in burrows, which have more than one doorway. In these burrows they bring forth their young. There may be as many as eight in a litter, and there is more than one litter in a summer.

They are very active; they are wont to rove about in search of food both by day and by night, and they do not sleep or even remain in their burrows through the winter, as so many other rodents do. So it is easy to understand that they require a great deal of food, and that a very good season, when abundance has caused multiplication to be even more rapid than usual, may be followed by a period of famine. Whenever scarcity threatens, the lemmings grow restless. They pour forth in streams from every part of the hillsides and the tundra, and gather together literally in millions. Soon they begin their hunger-trek, instinctively moving directly northwards. At first they are orderly enough;

they feed as they go, and when such a horde has passed over a cultivated patch not a living blade is left. They come to the banks of a stream, and they may be seen running up and down searching for a safe place to cross. But as time goes on they become panic-stricken and desperate. Their march is now a headlong flight, and if a broad river stretches across their path they throw themselves in and swim to the other side—those who can. Those that get safely across press on more wildly than ever.

All the time a heavy toll is taken by what one naturalist calls the "funeral procession" which follows them—owls and hawks, lynxes, foxes, and weasels. Disease thins them, too, the weakly ones fall out, and many of them get killed in strange ways. In the autumn of 1923, for instance, it was reported that lemmings were passing along the highways of Norway, and that great numbers of them were killed by motor-cars. Many may be drowned in trying to cross the fiord.

Not all the lemmings, however, come to such a tragic end. Some of them make good, and find new fields; some of those that dropped out recover from their exhaustion, and in a very few years the little lemmings are abundant again over all the northern plains. It is the old story: the individuals may perish in millions, but Nature takes care that the race is safe.

XI

SOME STRANGE MAMMALS

The giant Hippo is now rare except on the forest rivers in the interior of Africa. The hippopotamus is " behemoth " of the Old Testament, " the chief of the ways of God."

" Lo! now his strength is in his loins
And his force in the sinews of his belly.
He bendeth his tail like a cedar;
The muscles of his thighs are knit together;
His bones are pipes of brass;
His limbs are like bars of iron."

A full-grown hippopotamus weighs about four tons, and may be as much as fourteen feet long—a veritable giant. Its huge rounded body is supported on short, thick legs. Its massive head, with its broad muzzle and enormous teeth, is so heavy that the animal is sometimes seen resting it on the ground, as though even its thick neck could scarcely bear the strain of its weight. The body is almost hairless, and its hide much smoother than that of the rhinoceros.

The hippopotamus feeds on grass and water-plants, its stomach can hold five to six bushels! The German naturalist, Brehm, describes the hippopotamus feeding in this way: " The hideous head disappears into the depths, and grubs about for a few minutes among the plants, till the water is darkened with mud. Then 'Behemoth reappears with a great thick bundle—for him a mere mouthful—lays it on the surface of the water, and consumes it at his leisure. The stalks and tendrils hang far out of his mouth on either side; a greenish plant-juice mixed with saliva flows continually over his swollen lips; half-chewed balls of grass are thrown out and swallowed again; the expressionless eyes stare fixedly, and the great teeth exhibit themselves in all their monstrosity."

The hippopotamus is enormously strong, a mere push from its snout is enough to overturn a boat, and it can drag cattle under water quite easily. It does great damage in cultivated districts, where it raids the rice-fields and destroys with its its feet far more than it eats. But on the whole it is afraid of the settlers, against whose guns it has no defence, so in inhabited districts it is active only at night. During the day it remains under water. Its nostrils are placed high on its snout, and it keeps them above the surface, but usually well hidden among the water-weeds, so that there is nothing to betray its presence. It makes no sound during the day, except by its breathing, but at night it bellows and grunts and snarls.

In out-of-the-way regions, where there is little chance of its being disturbed, the hippopotamus is not nearly so nocturnal in its habits. It comes boldly out of the water in the daytime, and basks in the sun. Sometimes the calf—there is usually only one at a time—is left under cover to sleep during the day, but often the mother swims with the young one on her back. She herself can remain under water for fully ten minutes, but she comes up oftener when she has a calf, as it must breathe more frequently. If danger threatens, the mother is very brave in defence of her young one.

Mr. Blayney Percival describes how a "mud-bank" on an African river turned out to be the backs of fully a hundred hippos. They were not in the least alarmed, and two or three of them came swimming towards the observer to see what he was doing. He also tells of the "most charming and comical scene of animal life" he ever witnessed, a gathering of hippos at a favourite resting-place. "They came singly, in twos and threes, old and young, and they laid them down in a mass, literally in heaps, for it seemed the recognised thing that they should use each other as cushions. They lay there in the sun like dead things—at least the old ones did. The calves were less reposeful, walking round and over and among their seniors, and small blame to their restlessness. If a little fellow did lie down, a big one always came and sat on him; it was manifestly hippo tradition

to use the children as pillows. Down the big one would go atop of the unfortunate toto, and then a pardonable tempest of squeals from the half-crushed sufferer till he succeeded in wriggling clear of the ponderous mass, which took not the slightest notice of his screams and struggles. Having escaped, the little one would shuffle about a bit, then, finding himself comfy, go to sleep." The crowd of hippos on the bank took not the smallest notice when two huge ones in the river had a disagreement. A terrific fight followed, with much grunting and biting and churning of the water, but the slumberers never moved, and presently the battle ended as suddenly as it had begun.

THE RHINOCEROS

The rhinoceros has rather an evil reputation. It is said to be ill-tempered and malicious. It is undoubtedly inquisitive, and it has very indifferent sight; moreover, it is naturally an animal of the night, and spends most of the day in sleep, so that when it is wakened suddenly by a blundering traveller, it is apt to charge. The forest rhino, which has long, tapering horns, is probably more ill-natured than the rhino of the plains whose chief desire is to be left alone, though it will make a savage attack if it is disturbed. Originally an animal of the plains, the shorter horned rhinoceros has been forced further and further into the bush, and then into the forests by the advance of the settlers in the open country. Its food on the plains, namely, small thorn bushes and, perhaps, grass, is replaced by leaves and twigs in the jungle.

There is only one young one at a time, and it runs beside its mother till it is quite big. A mother rhinoceros has been seen accompanied by two young ones, a very small one and a big one that was obviously an older brother; but usually the mother drives away a well-grown youngster and lets it shift for itself before its successor arrives. During the day the rhinoceros sleeps, usually alone, lying under a solitary tree on the plain or in the shelter of a thorn-bush or in the heart of a thicket in the jungle. In rocky places it often

chooses a high ledge, for, in spite of its unwieldy body and short, thick legs, it can climb like a goat. It will lie stretched out on its side, like a huge pig, for hours without moving, while the tick-birds search its tough hide for food. Its sleeping-place in the forest is usually well away from water, on high ground.

About four o'clock in the afternoon, when the heat is less intense, the rhinoceros bestirs itself and starts its daily journey to its favourite watering-place. It feeds as it goes, wandering in a leisurely way from bush to bush, but it manages to reach the " edo " early in the evening. If it is late it will stop feeding and break into a trot, for, in spite of its stumpy legs, it can cover the ground at a good pace, and arrive at the water at the usual time. Rhino-trails, about twenty inches wide, and worn smooth by constant traffic, lead to the water-holes. Where they go through dense thickets, they are tunnels, just the height of the animal's body. They are not safe tracks for an explorer to use, any more than a rhino-trail is a good camping-spot, for these animals are very faithful to old paths, and use the same ones for a very long time.

Numbers of rhinos meet at the watering-place, and when they have quenched their thirst they begin to play, " romping like a lot of overgrown pigs." Their squealing and grunting resound through the dark forest. When they are tired of playing, they return to the water to wallow, or seek a convenient tree against which to scratch their wrinkled hides. Apart from the daily excursion to the water-hole, the rhinoceros wanders little for the greater part of the year, but seasonal wanderings take place when the driest months come. The rhinoceros finds its favourite water-holes dried up, so it sets out in search of deeper pools. It has a keen " water-sense," and is known actually to dig for water, using its fore-feet and throwing up the sand between its hind-legs, like a dog. Other animals make use of these holes, and may deepen them a little, but very few sink wells for themselves.

THE OKAPI

The tropical forest of Central Africa is the home of a rare and little-known animal, the okapi (*Okapia johnstoni*). Rumours had been heard of a strange, shy creature that roamed through the forest ; some said it was an antelope, others said it had stripes like a zebra, but it was not until the year 1900 that Sir Harry H. Johnston made the okapi known to Science. Even now no one has succeeded in bringing a living one to this country, although one survived for a short time in the Antwerp Zoological Gardens. Perhaps the only people, besides a few daring explorers, who know the okapi really well are the strange Pygmy natives of the Ituri forest. These sharp-eyed, agile little men are expert trackers, but even they find it easiest to catch the wary okapi by trapping it in a pit dug in the ground.

The okapi is related to the giraffe, but the line of its back is not markedly giraffe-like, for the shoulder is very little higher than the croup. Its neck is not very long, but its head is giraffe-like, with large, thin shell-like ears. Its colour, like that of many forest animals, is a deep chocolate or purplish-red, but broken up by white stripes on the hind-quarters and by white on the face and legs. The " horns," which occur in the full-grown male okapi, are similar in shape and development to those of its relative, the giraffe. Some years after the animal reaches maturity the horns, which are then two or three inches long, become firmly fixed to the skull, but they do not remain entirely skin-covered, as the giraffe's do, for they become bare at the tips, showing the bone below. They never have any horny covering as is seen in the buffalo, they consist entirely of bone. The female okapi, which is hornless, is larger than the male, which is unusual among hoofed animals. The height of a big female from the hoof to the highest point of the shoulder may be as much as five feet, while the length from the tip of the nose to the end of the shortish tail is over seven feet.

The footprints of the okapi are not unlike those of a donkey, but quite unlike the hoofmarks of a buffalo or a forest hog,

for the two halves of the cloven hoof separate so little that the division is scarcely seen even on soft ground. It is by the footprints that much of the animal's story is known. By them the tracker can tell when it wandered alone and when it met with its mate. For weeks at a time a pair of okapis will roam about a certain area of forest, perhaps extending several miles, each one going its own way for the most part, but, as the tale of the footprints shows, keeping in touch with one another and meeting every now and then. When there is a calf the parents meet more frequently, or even wander about together, with their youngster beside them.

The okapi does not like swampy ground, it avoids mud and soft earth, preferring whenever possible to tread on leaves. Nor does it like the dense, leafy jungle, for it is not so powerful as the red buffalo, which can force a passage. It chooses rather the well-drained ridges or the high ground near some stream. It roams far during the evenings and the early mornings, but during the day it keeps to the gloomy, silent aisles of the forest where the big trees are biggest, and the canopy so thick that the underwood is thin and upright. When it is feeding it seeks a spot under a big tree, where sounds carry well, avoiding thickets where it might be taken by surprise by its enemies. With an unbroken canopy overhead sounds carry far, and rustling leaves or snapping twigs give warning if anything is coming near. But in the silent depths where " this spectre of the forest " loves to roam there is little to disturb it. The cry of a hornbill or the shout of a chimpanzee will not alarm it, though sometimes it may take fright as an elephant crashes past or a giant forest-hog comes grunting through the gloom.

When the okapi bolts it carries its neck straight in front, or even lowered, just as a running giraffe does, but when it stands listening the neck-line is higher. Its hearing is very acute, and it has a keen sense of smell ; its broken colouring helps to conceal it among the shifting lights and shades of the forest, so it is a very difficult creature to track. When it is surprised it gives a sudden snort or " blow," like the

giraffe's, the only sound it ever utters, as it turns and runs for safety. It feeds chiefly in the late afternoon and early morning, on the leaves of young saplings among the underwood. It never eats grass, for, as we have seen, no grass grows in its favourite haunts. Its long, muscular tongue is very well suited for hooking down the leaves. The okapi's kinship to the giraffe must be most clearly seen when it is feeding, stretching up to its full height, with neck extended, and curling its long tongue round the leaves of the trees.

THE BONGO

Although dark brown striped with white sounds a somewhat striking colour-scheme, in reality it has great advantages to the animal in concealing it from its enemies, and the bongo, another animal of the African forest, has the same kind of colouring as the okapi. The bongo (*Boocercus eurycerus*) is a handsome animal of the antelope tribe, and its dark chestnut coat striped with white is a good example of protective coloration. The white lines break up the outlines of the body, so that it merges with the background in the bongo's natural haunts in the forest, making it quite inconspicuous, especially when the sun is shining and the forest is full of contrasting lights and shadows. In just the same way the bold stripes of the tiger make it almost invisible in its particular haunts. Desert animals must have plain, dun-coloured coats for concealment, but in forest and jungle broken lines and colour contrasts make for security.

The bongo's home is in the forest, but it roams far afield to bamboo jungles and swampy ground. Unlike the okapi it is fond of soft ground, and spends a good deal of time wallowing in the swamps. Although it is a wary animal, it has one habit that often leads to its undoing, it returns again and again to a favourite wallow-hole, and, moreover, uses the same paths each time, which may lead to its being trapped by the Pygmy natives. It is a powerful beast, with massive horns which it has a trick of rubbing against trees till they are highly polished. When the okapi is

making its way through the forest it tends to go over obstacles whenever possible, but the bongo has a positive aversion to jumping. It will scramble or crawl round or under anything, but it will seldom take a clean leap over a bush or a fallen tree. This habit it shares with the little red buffalo of the forest. Perhaps the uneven ground and the numerous tangles of creepers make jumping inadvisable in the dense parts of the forest.

ARMOURED MAMMALS

As examples of well-armoured mammals the armadillos must be given a foremost place. They are provided with a bony shoulder-shield and a bony hip-shield, and between these there are girdles of bone which move readily on one another when the animal tucks in its head and tucks in its tail and rolls itself up into an unopenable ball. The armadillos and their relatives are the only mammals that have bone in their skin, and their armour is almost perfection, not only because it is so strong, but because it can roll up. The armadillos belong to the same order as the Sloths, but whereas the slow-going Sloths have taken refuge among the branches, the armadillos keep to the ground and trust to their armour and to their power of quick burrowing. They have very strong claws, and some of them disappear very quickly into the earth, sinking straight down, so that the last part of them to be visible is the middle line of their back, covered as we have mentioned with bony plates. This does not give the enemy much to grip at! There is a large armadillo discovered not long ago which, besides being armoured, can run at a good pace and give a vicious bite.

There is a saying, "You cannot have too much of a good thing," but perhaps there is more wisdom in the Latin motto "Nequid nimis," or "Nothing in excess." For in animal races we sometimes see what looks like carrying a thing too far, as, for instance, in the South American Glyptodons, extinct relatives of the armadillos, which had armour an inch thick, surely much more massive than was

necessary. But the same sort of thing is to be seen among men and nations!

Before we leave the armadillo's armour, perhaps we may be excused for making two notes that are a little away from the point. The first is about Charles Darwin, who was greatly interested in the armadillos and their relatives—both living and fossil—which he found in South America when he was on his famous voyage of the *Beagle*. What made him think deeply was this: that South America is very rich in fossils of this order (Edentates), and it is also the headquarters of the living representatives. Now what Darwin said to himself, half in a whisper, was something like this: "It cannot be a coincidence. Surely these numerous *extinct* armadillos and ant-eaters and sloths must include the ancestors of those that are now so common in this region." This idea is accepted by all naturalists to-day, but it was Darwin who made it current coin. The other note is very simple, that the people of the country make very effective baskets out of the armadillo's armour. They remove the dead animal, turn the carapace upside down, and sling a handle from the head to the stump of the tail. You could not have a better basket for going to market with. The tendency to develop bone in the skin is very thorough-going, for there is a succession of complete bony rings around the tail, each one very suitable for a reliable and decorative napkin-ring.

The Pangolin, a relative of the armadillos, lives in Africa and the Far East, and has very strong scale armour. Very strong horny scales, overlapping like the tiles on a roof, cover the whole of the animal, and are movable one on another. Even when one knows better, it is difficult to look at this strange and very old-fashioned mammal without saying: "What a Reptile!" And perhaps the scales *are* a legacy from distant reptilian ancestors, for there can be no doubt that mammals sprang from a stock of extinct reptiles. Perhaps, however, it would be nearer the mark to say that mammals have not quite lost the reptile's power of producing scales, for we find scales on the tails of rats and beavers. Among the Oriental Pangolin's scales, and



Photo : F. W. Bond.

WHITE-BELLIED PANGOLIN, ARMOURED WITH HORNY SCALES.

These toothless, scaly pangolins have a very long sticky tongue, with which they catch ants and termites. They are not suited for arboreal life, but they have been known to climb to a considerable height after insects. The species photographed has an unusually long tail.

in the young of the African species, there are hairs. We may also mention that there is an interesting dolphin which has scales imbedded in its skin, just as some of the extinct whales had.

There is a certain amount of armour in having a thick skin, and this reaches a maximum in rhinoceros and elephant.

XII

INSTINCT AND INTELLIGENCE AMONG MAMMALS

MANY well-known mammals have inborn powers of doing clever things, *which do not require any learning*. These inborn powers are called instincts, and they are not on the same line as intelligence. They are seen at their best in ants and bees, where the animal does a difficult thing the very first time it tries, and yet does not seem to understand what it is doing. In mammals and birds, however, the instincts seem often to be accompanied by some intelligent supervision, so that if there is a hitch in the proceedings, understanding is able to suggest a way out. This is very rarely seen in lower creatures—very high in their own way—like ants and bees.

What, then, among the ways of mammals would be called *instinctive*? The way in which a beaver cuts with its chisel-edged teeth all round the base of the tree till the breeze snaps the narrow core. The way in which a squirrel stores nuts for the winter, and the mole a collection of earthworms, each with its head bitten off. The way in which a harvest-mouse builds a neat nest among the stems of corn. The way in which a mother-hare leaps out of her " form " when she is going on an excursion and takes a long jump in again when she returns, so that the scent is broken and the cradle of her young ones is not betrayed.

LEARNING AMONG MAMMALS

Lord Avebury had a dog called " Van," which was taught to link together the sight of certain printed cards and some desirable experience. When it wanted a walk and saw that there was some chance of it, what did it do but go to the

box of cards and select the one marked " OUT " ! In other circumstances it would go to the box and select the card " TEA." But we must not be too generous in thinking over this kind of behaviour ; the dog had simply learned



COMMON BROWN SQUIRREL (*Sciurus vulgaris*).
In its alertness, its nest building and its habit of storing against winter scarcity, this fascinating animal shows instinctive and intelligent qualities of a high order.

to link together in its mind certain black marks and certain desirable things, such as a walk or a meal.

Some dogs know without mistake what a particular kind of whistle means, and others link together the sound of a special motor-horn and their home-coming master. There was a

setter that used to *say* " Don " when he was asked his name, and " Hunger," when he was asked what ailed him, and " Cake " when he was asked what he wanted. Visitors were much struck with the glib way in which the dog gave the answers to those questions; but one day a scientific visitor arrived, and he began by asking the dog what ailed him, whereupon the dog said " Don." It turned out that the owners of the dog had always put him through his catechism in the same order. All that the dog had learned was that the first question must be answered by a sound more or less like " Don," and the second by a sound more or less like " Hunger." There was an association established, but in this case it did not seem to get beyond an association between certain answers and the *order* of the questions.

In many cases, however, dogs are able to distinguish the sounds of particular words and to link these to certain doings of their own. This is very important in Natural History, for some young animals in Wild Nature spend a good deal of time in learning to connect certain sounds in the woods with particular pieces of behaviour.

A bull-terrier called Jasper was carefully studied by Professor John B. Watson. From behind a screen the owner, Mr. Dixie Taylor, would say in a quiet tone of voice: " Go into the next room, Jasper, and fetch me a paper lying on the floor." Jasper would do this at once, and was only at fault when there were several objects in a row on the floor. For then he did not always bring the right one. He might bring a slipper instead of a newspaper. Down on the street, Mr. Taylor said to Jasper: " Go behind me and put your feet on the bicycle." The bicycle was about fifty feet behind Mr. Taylor, but the dog trotted immediately to it and did as it was told. The command to go and put its feet on a motor-car about a hundred yards off was executed with equal readiness. The dog had been taught to do these things, and it recognised the sound of a particular word or of several words as the signal which it knew should be followed by a certain performance.

We do not profess to be able to explain all the wonderful things that performing dogs are said to do, but a large

number of the wonders are covered by the term "linkage" or "association" or "conditioned reflex." In the course of tuition, the creature learns to do a particular thing when it sees or hears a particular signal.

Many mammals are very quick learners, and people who do not know of the many lessons are apt to be too generous in their admiration. Of course it is all admirable, but it is not always so clever as it seems. There was an elephant at the Belle Vue Gardens, in Manchester, that used to take a penny from benevolent visitors, put it into the slot of an automatic machine, and thus get a biscuit. But if it received only a halfpenny from the visitor, it used to fling it back with disgust. "How clever of it!" people used to say, but every stage in the performance had been the subject of careful training. The elephant had its trunk patiently guided to the machine, and it required two or three months' schooling before it learned to distinguish between the penny that worked and the halfpenny that did not. A spice of intelligence there was, but not nearly so much as at first sight appeared. Some mammals, such as pigs, are much cleverer than they look, but there are many that seem to be more intelligent than they really are.

Many mammals, such as rats, show considerable quickness in learning to find their way into the centre of a labyrinth or maze. The animals are first accustomed to take their meals in the central chamber of the maze, and then they serve an apprenticeship to finding their way in. They learn best, naturally enough, when they have a good appetite. In the course of days they make fewer and fewer mistakes. They get rid of useless movements. Finally, in some cases, they do not make any mistakes at all.

Many interesting experiments have been made with a peculiar variety of mouse—the Japanese Dancing Mouse—famous for its whimsical habit of waltzing round and round, without any obvious reason. There is something wrong with its constitution, but what that precisely is we do not know. It is an animal that could not possibly survive in Wild Natuie, but flourishes fairly well under man's protection. Its interest for us just now is that it can learn some lessons

quickly. Professor Yerkes took the Dancing Mouse for his pupil, and one of the lessons was to distinguish between two pathways marked by different illuminations and different colours. If the mouse chose pathway A, it found a clear passage to its nest; if it chose pathway B, it was punished by a mild electric shock and had to take a roundabout way home. In the course of time, the mouse learned the lesson perfectly, and went right into pathway A without making any mistake. It will be understood, of course, that precautions were taken so that there were no smell-traces to help the mouse. Moreover, the A compartment was sometimes to the right hand, sometimes to the left, else the mere position would have counted. What is clearly proved is that a mammal may learn in a short time to distinguish between comparatively slight differences in light and colour. This kind of learning is likely to be very useful in Wild Nature. For there is no doubt that clever mammals, such as foxes, are very quick to notice that some slight change has occurred—some new sound or scent, some new shadow or movement, which must be regarded with suspicion. This is at the root of what we describe as wariness.

INTELLIGENT BEHAVIOUR

We have seen that some of the mammals have inborn cleverness or instincts, and we have given examples of the way in which they learn to connect certain sights and sounds with certain actions of their own. But the most interesting question is: Do mammals think? Do they profit by experience in an intelligent way? Can they put two and two together so that we feel bound to say that they are understanding in some degree what they are doing?

When we watch collie dogs at a shepherding competition, where they are set problems such as bringing sheep back to the fold along a difficult path, or separating two flocks that have got mixed together, we feel inclined to be very generous. The dogs behave as if they *understood* what was wanted of them. We get the same impression of intelligent interest

when we watch the ponies at a polo match. Many observers would agree with Kipling that a clever pony enters into the game and may help its rider intelligently. We have often watched a horse doing shunting work near a railway station, and have turned away convinced that if the behaviour is not intelligent, it is an extraordinary close imitation of the genuine article. The same may be said of the behaviour of the elephant helping the woodman in the Indian forest. In these cases—dog, horse, elephant—we are dealing with mammals endowed with very fine brains, and we need not be stingy. It has to be remembered, however, that they serve an apprenticeship and that they work in co-operation with man, which must help to excite their intelligence. Can we find other instances ?

In the beautiful " Zoo " in Edinburgh some of the large mammals live in old quarries, so that the visitors have the pleasure of seeing them against an interesting background of rock, and not through iron railings. A Polar Bear, when we saw it one day, was sitting on a promontory projecting into the water of the quarry. The kind-hearted visitors had thrown it buns, and many of these had fallen short and were floating on the surface. It would have been easy for the bear to have plunged into the water and secured them, but it was not so inclined. What we saw it do was of interest. It came to the edge of the rocky promontory and began scooping the water with its huge paw. This produced a current, and as the bear continued scooping skilfully, the buns came floating past and were captured. Of course we would not base any large conclusion on what we happened to see once, but it seems very likely that the bear's behaviour should be ranked as intelligent. The bear did in some way put two and two together—it used old means towards a new end.

A dog, carrying a basket of eggs by the handle, came to a stile ; it poked the basket through at the foot, ran back a few steps, took the stile at a bound, pulled the basket through, and went on its way. A dog, afraid of the water, entered a *strange* boat to follow its master across a river. During a bad flood in a meadow near a river a number of mares



From Prof. Wolfgang Kohler's "The Mentality of Apes," by permission of the publishers. Messrs. Kegan Paul, Trench, Trübner & Co. Ltd.

CHICA ON THE JUMPING STICK.

Professor Köhler's chimpanzees showed a high degree of intelligence in their open-air enclosure at Teneriffe. To reach tempting fruit hung high above its head, this one invented a jumping-pole. It used to climb up, snatch the prize and then jump off before the pole fell.

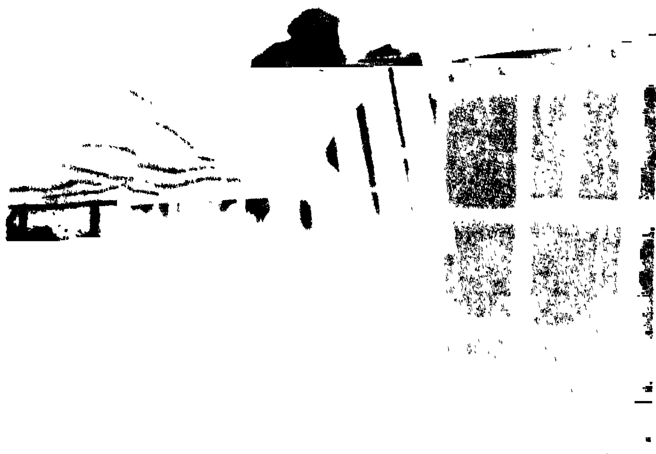
herded their foals to the top of a hillock and kept them in the centre. These are instances of behaviour to which we should be inclined to grant the title of *intelligence*.

But we must turn again to Professor Köhler's chimpanzees (*The Mentality of Apes*, 1925), for the observations were made with unusual carefulness, and the animals were kept in very wholesome conditions at Teneriffe. The results show that naturalists have hitherto under-estimated the intelligence of these apes.

An animal of higher degree makes as directly as it can for a desired objective, such as food. But if the direct way is blocked by bars or other hindrances, it seeks for a roundabout way; and we may judge of its intelligence by the nature and number of the trials it makes. Köhler's chimpanzees were very quick to appreciate any such situation, as the following experiment shows. The objective was a heavy basket hung from the wire roof, but not reachable from the ground. A push made the basket swing for some time, and its longest swing to one side brought it within reach of a scaffolding. "Thus the roundabout way is easily recognisable, and available, but only for a few moments." The basket was set a-swinging and three chimpanzees, Chica, Grande, and Tercera, were let in. Grande leapt directly from the ground and *missed*; but Chica, after quietly surveying the situation, clambered up the scaffolding, waited with outstretched arms for the basket, and caught it successfully.

Grande did the same when the test was repeated, and every chimpanzee can solve this sort of problem, which seems, one would think, to require a spice of judgment.

A chimpanzee will pull in a distant object which has a string running from it into the cage, but if the string-end and the object are wide apart it will not usually try to pull in, unless it is interested in the string as such. An object may be pulled into the cage by using a stick; a banana out of reach may be captured by swinging vigorously on a rope; some fruit fastened to the roof may be obtained by pulling a box to the proper place and mounting on the top; sometimes a stick was used to eke out the vantage of the box.



From Prof. Wolfgang Köhler's "The Mentality of Apes," by permission of the publisher, Messrs. Kegan Paul, Trench, Trubner & Co. Ltd.

GRANDE ERECTS A FOUR-STOREY STRUCTURE.

Another of Professor Köhler's chimpanzees proved its mental powers by piling four boxes, one on top of the other, in order to seize a banana suspended out of reach.

In their school—it was at Teneriffe—the chimpanzees made many inventions, such as a "jumping-pole," which they climbed up and jumped off before it fell, a lever for breaking boxes and bolts, a spade for digging in the ground, and a stick for fighting with. Of course the apes were never taught anything; they were simply given opportunities of finding out for themselves. An interesting game was holding a slice of bread, which they do not much appreciate, through the bars for a hen and then drawing it back just before the peck came; or else letting the fowl peck and then prodding her forcibly with a stick or a wire held in the other hand. On a few occasions two of the chimpanzees fed the fowls with bread and watched the meal with great interest—but this was simply a play, certainly not "altruism."

When one of the chimpanzees was trying to reach a banana with a stick that was too short, it sometimes took another and shorter stick and laid the two in line so that the outer end touched the objective. This was of no avail, of course, but it was interesting; and soon afterwards, being provided with two bamboo rods, one smaller and shorter than the other, the chimpanzee fitted the shorter into the longer, made a double stick, and reached the objective. This was an achievement, and the invention was made in the course of a day's experimenting. Chance may have helped, just as it sometimes helps man, but the chimpanzee profited by the chance!

To reach a treasure fastened to the roof a chimpanzee will mount on the shoulders of another or on the top of a box. On one occasion when a box was pulled to the right place, the fruit was still beyond reach. The animal then jumped down, considerably out of temper; it seized a smaller box and ran round the room, cursing and kicking. "He certainly did not seize the second box to put it on the first; it merely helped him to give vent to his temper." But quite suddenly his behaviour changed; he stopped making a noise, pulled the second box to the first, and lifted it on to the top. Sometimes rather shaky four-storey edifices were erected, and this reveals a real power of putting two and two together.

These are but a few samples of the highly interesting observations which Professor Köhler records in his valuable book. They prove considerable intelligence on the part of the chimpanzees, but it must be noted that there are many cases which show limitations almost as striking as the achievements. Chimpanzees are inventive when they get a visual grasp of the whole situation, but they are puzzled by an optical complication that a little child sees through at once. They seem to be handicapped by their slender capacity for "image-forming," and, of course, by their poverty of speech. But they are wonderful creatures, certainly not poor relations of whom to be ashamed.

Some people refuse to do justice to monkeys, being repelled by their resemblance to man; and they do not take the trouble to understand clearly what Darwin taught in regard to man's pedigree. In the first place one must remember that monkeys and apes form a large order (Primates) of mammals, with great diversity amongst themselves. Thus, there is a huge distance between ordinary monkeys and the anthropoid apes. But though the anthropoid apes come nearest man, it is not supposed that any living ape is man's ancestor. That is quite out of the question. What Darwin taught was that primitive tentative men diverged long ago from a stock common to them and to the anthropoid apes. This momentous divergence, leading on towards Homo, probably occurred not less than a million years ago. The anthropoid apes remained arboreal and not very progressive; tentative men continued a terrestrial evolution, becoming more unique and wonderful. It is not in his ancestry that man can suffer loss of dignity.

XIII

THE STORY OF THE ELEPHANT

THERE is nothing in all the living world to-day that is in the least like an elephant. It is true that in many points his structure shows that he is distantly related to the other hoofed animals, and that he must have had a very far back ancestor in common with them. But in most respects he stands quite alone. His huge size, his straight, pillar-like limbs, his short neck, his enormous head carried almost horizontally, and, above all, his wonderful, elastic and sensitive trunk—all these make a whole to marvel at, an animal that looks out of date in our modern world, as though he were a survivor of ages long gone by. And this, indeed, is what he is.

Elephants are now only to be found in the hotter parts of Asia—the Indian jungles, Ceylon, Sumatra and a few other islands, and in the wilds of Central Africa. But millions of years ago, long before man existed on the earth, animals very like the elephant wandered over the greater part of the Northern Hemisphere, and even lived within the Arctic Circle.

We know this from the abundant fossil remains that have been found, and from these, too, we have learnt something of the different forms that succeeded each other through the ages, from the time that the first forerunner of the Proboscis-bearers struck out on a new path, away from the common stock of the hoofed animals. " The fossils, so far as is known, show that the earliest forerunners of the elephant were small marsh-dwellers which lived on succulent food in the African region. They gradually increased in size without essentially altering limbs and body, but as their legs lengthened and their neck shortened, their face and chin became gradually elongated to reach the ground for browsing." At that stage

the tusks were in the lower jaw, and were apparently used for grubbing in the earth. The neck then, as now, had to be extremely strong, and therefore was too short to admit of the animal reaching the ground, and the lengthening out of the lower part of the face was one of the first ways of solving the difficulty of feeding. But as time went on, Nature found a better way.

The chin shrank, the tusks developed in the upper jaw, and those in the lower jaw became less and less prominent, till finally they were only seen in very young animals; the snout began to lengthen out, and at last the trunk was fully developed. The stages through which the trunk passed can only be guessed at from the changes in the skull, for soft parts are rarely preserved as fossils.

As ages passed—long, long ages, for " they say it must have taken two million years for the lower tusks to wear away " —we come to forms very like our own elephant. Most of them were as large as, if not larger than, the modern elephant, but the remains of an interesting race of " pigmy " elephants, many of them no larger than a sheep, have been found in the islands of Malta and Cyprus. These, we are told, are probably descendants of some larger forms that were stranded on the islands when some geological change cut them off from the mainland, and in the restricted space, with limited food supply, the stock became gradually smaller, as island-animals—witness the Shetland pony—are well known to do.

The prehistoric form of elephant about which we know most is the Mammoth, for, as already said, it lived on long after man had appeared. Not only are its remains found along with those of primitive man, but pictures of it have been found on the walls of caves, and carved by man's hand on the ivory of its own tusks. The mammoth was of the size and type of the Indian Elephant, but it was covered with a thick coat of short reddish wool, interspersed with long black hairs. Its bones and teeth have been found all over England, the north of Europe, North America, and in the remotest islands of the Arctic seas. Indeed, " the farther north we go the more numerous they become." So abundant are the

heaps of bones and teeth that a trade in fossil ivory has been carried on for more than two centuries, for the mammoth bore a fine pair of large curved tusks.

In addition to these heaps of remains, several whole animals have been found in an upright position well below the surface of the ground, as if they had sunk bodily into a marsh, or been suddenly overwhelmed by a landslide. The frost of these regions has preserved the animals all these thousands of years, so that flesh, skin, and hair are all intact, and in one or two cases even the last meal of grass or pine-shoots was still fresh in the stomach.

The mammoth has long since died out, but the elephant, which existed along with it, holds its own still. How has it been able to survive so long? Perhaps if we look at it for a little in its native surroundings we shall find at least part of the answer to that question.

PECULIARITIES OF ELEPHANTS

There are two kinds of elephants, the Indian or Asiatic, and the African. The Indian form is the smaller of the two, but a full-grown male stands from nine to eleven feet high at the shoulders. His great body is covered with a thick, much-wrinkled skin, with only a few sparse hairs. The folds of the skin afford a favourite feeding-ground and hiding-place for many insects, and the elephants are very often seen with insect-eating birds on their backs. The birds get a comfortable living there, and the elephant tolerates their presence for the comfort they give by relieving him of his parasites.

The elephant's neck, as we have said, is very powerful, but so short that it gives no great range of movement to the huge head. The head must be strong enough to bear the weight of the heavy tusks, and have a large enough surface for the insertion of the great muscles needed to move the trunk. The elephant often uses the bony part of the head above the trunk to push things over, or as a kind of battering-ram, and the reason that he can do this without hurting himself is that there is a very large space, more than a foot

in extent, behind the strong outer layer of bone, which is entirely filled with a network of air-spaces separated by very thin bony plates. Similar air-cells are found in the bones of the nose and jaw, and they all communicate with each other, and ultimately with the nostrils, so that air can penetrate into them all. Thus the enormous head is not so heavy as it looks, and it is not at all a vulnerable part of the animal, for a bullet aimed at the forehead simply loses itself almost harmlessly in the labyrinth of air-spaces, and never reaches the brain at all. The brain is larger than that of any other animal, living or fossil—even the whale.

The " milk " front teeth or incisors of the young elephant are shed at an early age, and their place is taken by the tusks, which go on growing throughout life, and often reach a very large size in the male. Those of the female are shorter and less curved. The tusks are made of fine elastic " dentine," with just a tip of enamel which is soon rubbed off. The dentine is the valuable ivory of commerce. The elephant uses his tusks for many purposes—rooting up plants, piercing or holding down an enemy, or supporting a heavy weight held in position by the trunk. Yet he is always careful to keep them from getting broken.

But it is the trunk or proboscis that gives to the elephant its chief distinction. This wonderful organ is a prolongation of the nose, which, however, takes in part of the upper lip. It is a long straight tube, divided down the middle, very elastic and mobile because it is made up of rings of muscle, very sensitive because it is well supplied with fine nerves. The upper part ends in a finger-like projection, " which rivals in delicacy the trained fingers of a blind man." The elephant's trunk serves all the purposes of a hand, an arm, and a lip as well. With it he tears up the juicy plants on which he loves to feed, and puts them into his mouth, or breaks down the branches of the trees and strips them of their bark and leaves, or trims one into a fan, which he uses to drive off the flies that torment him ceaselessly by day. With it, too, he drinks, filling it with water, curving it round, and squirting the water into his mouth.

The upper part of the elephant's leg is long, so that the

" knee-joint " is low down. The bones of the feet are short and stumpy. There are five toes, fore and hind, but they are so firmly wrapped about with fibres and sinews that they cannot move independently, and there is no sign of them on the outside except the ends of the hoofs or crescent-shaped nails which surround the tip of each toe. This great foot, which " has the appearance of an enormous pavior's beetle with a broad, flat, undivided sole," gives the elephant its noiseless tread, but also furnishes it with a very formidable weapon.

The home of the Asiatic Elephant is in the great jungles along the foot of the Himalayas, and elsewhere throughout India, the Malay Peninsula, and some of the larger islands. They live usually in family parties of twenty to forty, but sometimes several such herds unite together for a time. The herd is under the leadership of an old " tusker," to whom the rest yield unquestioning obedience. The females and young ones lead the way in marching, and the males bring up the rear. Many of the adult males live alone except during the mating season, but sometimes a male tries to assert himself, and seize the leadership of the herd. Unless the old leader has become feeble he rarely succeeds, and is usually driven forth altogether. No other herd will admit the stranger, and thenceforward he leads a lonely life as a " rogue." Such rogues become very ill-tempered as time goes on, and are often very dangerous.

Those living in herds in the normal way are very peaceable among themselves, and towards other animals and man, whom they rarely attack. " Nature," says Mr. Lockwood Kipling, " in furnishing the beast with a soft and tender trunk, has bound him down to keep peace with all creation." When the elephant does charge he carries his trunk tightly coiled up, and takes great care to keep it from being injured, for he cannot live without it, and " though protected by a pair of sharp bayonets, it is as vulnerable as a garden slug." No animal will venture to attack a herd, and even a tiger is scarcely a match for a single elephant, unless he can manage to avoid being pinned down by the tusks or trampled under the relentless hoofs. Elephants are wholly vegetarian, and,

though they have their favourite food-plants, nothing in the way of grasses, leaves, or even young branches comes amiss to them. They do very serious damage by trampling and uprooting when they get into a plantation, and the Indians have to keep constant watch over their rice-fields. They build a high, strong platform near them, and two men keep watch in turn. If elephants approach the men shout, beat drums, and make all sorts of noises to scare them away. This succeeds well enough with the cautious herd, but a "rogue" is not so easily frightened, and he will return night after night.

The herds never remain for long in one place, for they so quickly devastate a feeding-ground that new ones have to be constantly sought. They usually march after dusk, and they may go far up the mountain-sides even when it is cold. They climb very skilfully and carefully, the leader testing every rock and tree-trunk, the rest following in single file. A fall is a serious matter for an animal of such enormous bulk, so their caution is fully justified. Whether in the plains or on the mountain-sides, the one thing that seems absolutely indispensable to them is abundant water for drinking and bathing. Herds often stand up to their necks in water for hours during the hottest part of the day, and, if they cannot find pools deep enough for that, they fill up their trunks repeatedly with water and squirt it over their backs and sides.

The elephant's usual movements are ponderous, and a herd feeding in security makes a great deal of noise, but they can retreat without a sound if they are alarmed. The pace is slow, but so steady that great distances are covered in a night. An elephant can run for a long distance at ten miles an hour, and for a short distance much faster than that. He is a powerful swimmer, and a herd will cross a broad river, swimming for several hours at a time, with only the tip of the trunk above water.

A female elephant usually has one calf every two years. The baby is just about three feet high at birth, but growth continues for about twenty-five years. It sucks with the mouth in the usual way, keeping the trunk folded back.

It is said that any elephant mother will give suck to any calf in the herd, and there is no doubt that the young ones are kindly treated and caressed by all the members. The calf is precocious and able to move with the herd a few hours after birth. At first it walks in front of the mother, who guides it by laying her trunk along its back, but as soon as it has gained a little strength it runs under her body, and for a long time it retreats there on the least alarm. In swimming, the mother at first supports the young one with her trunk, but later, it is said, carries it more conveniently on her back.

The African Elephant is a good deal larger than his Asiatic cousin; his ears are much larger, his tusks heavier and rather more curved, and his trunk bears a finger-like projection below as well as above. The African Elephant has not been made use of by man since the time of the Cæsars, when it was much used in war and pageantry, and therefore it has not had the same measure of protection as the Indian Elephant now enjoys. So there has been little check on the killing of him for commercial gain, and his numbers are said to be fast diminishing. The favourite food of the African Elephant consists of the tender branches of the mimosa. But the mimosa grows very tall, and he cannot reach the branches with his trunk, therefore he uproots the tree. It is quite certain that some of the uprooted trees are too large to have been dealt with by a single elephant, and that they must have been brought down by the combined strength of several giants.

SECRETS OF SURVIVAL

We may now return to the question as to how an "old-fashioned" animal like the elephant has been able to survive so long. Part of the answer lies in its structure, which we have already considered, and in its perfect adaptation to the surroundings in which it lives. Its gregariousness is a point in its favour, too, for a compact herd with sentinels posted to give warning at the slightest unfamiliar sound has nothing to fear except from man and the weapons of civilisation. And even from these relative safety is secured by the dense-

ness of the forest in which the elephant lives, for it is hardly possible to penetrate into the interior of many parts of the jungle in Ceylon and the forests of Central Africa, except by means of the paths the elephants themselves have made.

Perhaps the chief reason for the elephant's survival, however, is to be found in his big brain, and the intelligence associated with it. He has very keen senses; his hearing and sense of smell are very acute, and his vision is good, though the field is limited. Yet many different opinions have been expressed as to his cleverness, that is, in the sense of being able to cope with unexpected circumstances. There is no doubt that a herd of elephants show much more intelligence in their ordinary life than any of the other gregarious vegetable-feeders, such as deer, for, though these follow a leader, post sentinels, and detect every unusual sign or sound, they never combine to attain some end as elephants are known to do. But in wild life the elephant does not behave so intelligently as the great Carnivores. This, however, is largely due to the difference in their mode of life. A vegetable-feeder, which can always find its food without difficulty, and must spend a great part of its time eating, because so much is required, has not the same need to develop cunning and foresight as the large flesh-eating animals, whose life depends on their skill in hunting.

The outstanding feature in the elephant's mental capacity is its teachableness, and it is in association with human beings that its cleverness is fully developed. It has long been admitted that the tamed elephant shows more intelligence than any other animal except the dog and some monkeys. But a recent authority who has had great opportunities for observing elephants, both wild and tame—Dr. Hornaday, Director of the New York Zoological Park—refuses to allow even the dog a higher place. He points out that the dog, which is allowed to roam freely indoors and out, has quite different opportunities from the elephant, which, because of its size, must always be caged or tied, and be led wherever he goes. Moreover, dogs are trained from their earliest days; it is no use trying to teach an old dog tricks. The great majority of tamed elephants, on the

OTHER TRUNKED MAMMALS.

Not every creature that has a trunk is a relative of the elephant. Figures 1, 2 and 3 show trunked mammals of widely different types which have developed a proboscis for protection or for feeding.



FIG. 1.—The Jumping or Elephant Shrew (*Macroscceles*). An African animal of the shrew family, which uses its slender trunk to probe the holes in ant-hills in search of insects.



Photos: W. S. Berridge, F.Z.S.

FIG. 2.—The Malayan Tapir, a relative of the horse and the rhinoceros. This pig-like mammal has developed a short projecting trunk or proboscis.

other hand, are caught when they are already mature, yet in a few months they have learned to obey many commands, and to remember a long series of actions. They have also good memories for people, and are capable of strong attachment to their masters, and recognise them after a long interval, while they will revenge themselves for any injury or unkindness long after it has been inflicted.

Dr. Hornaday tells us of an interesting use made by a small and very young African Elephant of its eighteen-inch-



Photo: W. S. Berridge, F.Z.S.

FIG. 3.—The Sea Elephant (*Macrorhinus leonina*). Found in Arctic regions, the full-grown sea elephant, a relative of the seals, has a peculiar trunk-like elongation of the nose, which is usually limp, but can be distended in excitement.

long tusks. He was being forced on to platform-scales, and was greatly alarmed by the trembling of the platform. He backed, trumpeted, and refused to move, but it was all of no avail against the steady pushing of the keepers. Finally "he fell upon his knees and drove his tusks into the ground, quite up to his mouth, to anchor himself to solid ground." Having once discovered this trick, he used it often when he did not want to be taken back from the exercising ground to his own quarters.

The elephant, though he is of great use to man, cannot be

EVOLUTION OF THE ELEPHANT.

From fossilised remains we know that the earliest forms of elephant were short-legged creatures, which in the course of countless years grew in stature. The trunk correspondingly developed to allow the animal to browse. Three stages of the process of evolution are shown in the following figures.

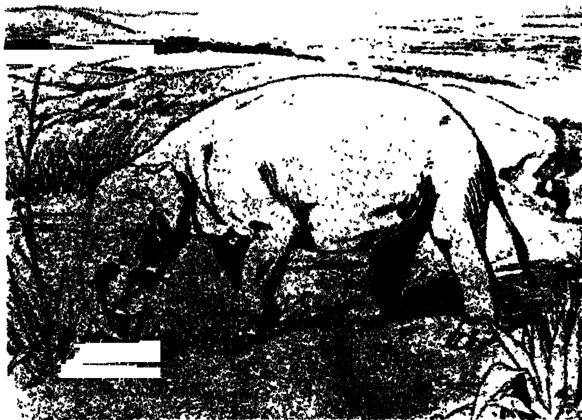


FIG. 1.—Restoration of Moeritherium, an animal about three feet in height.



Photos: E. J. Manly.

FIG. 2.—Restoration of Palæomastodon, height from four feet to six feet, according to species.

called a domesticated animal. Young ones are only rarely born in captivity, and their period of growth is so prolonged that it is easier to catch wild elephants to keep up the supply than to try to breed them. The method of capturing them by driving them into a kheddah or enclosure surrounded by stakes and then securing them with the aid of decoy elephants has often been described. "The conduct of the tame ones during all these proceedings was truly wonderful. They

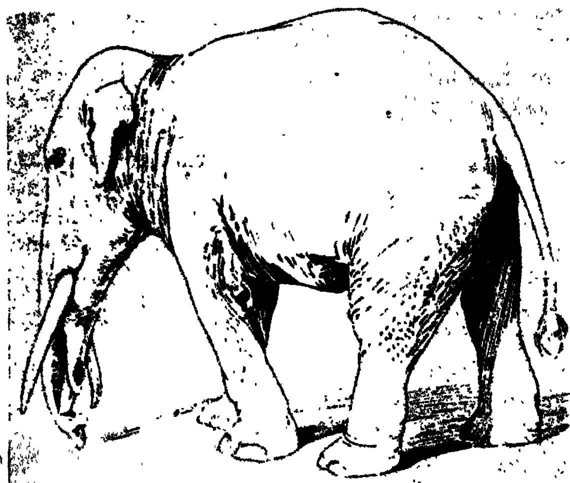


Photo: E. J. Manly.

Fig. 3.—Restoration of Tetrabelodon angustidens, about the size of an Indian elephant: with four tusks.

displayed the most perfect conception of every movement, both of the object to be attained and of the means to accomplish it. They manifested the utmost enjoyment in what was going on. They saw intuitively a difficulty or danger, and addressed themselves unbidden to remove it. On one occasion when successive efforts had failed to put the noose over the foreleg of an elephant which was already secured by one foot, but which wisely put the other to the ground as often as it was attempted to put the noose under it, I

saw the decoy watch her opportunity, and, when his foot was again raised, suddenly push her own leg beneath it and hold it up till the noose was attached and drawn tight." The captured elephants can usually be trusted to work without the company of a tame one after four months. The females alone are used for Government work, because of their greater evenness of temper, but males are also caught, and are sold to merchants or to native princes, who value them highly for purposes of display. The "white elephant," or albino, which is light in colour though not white, is especially sought after.

Where roads have been made the elephant has been largely displaced by motor traction, but over rough and hilly ground it is still greatly used as a pack animal. It is also much used for piling timber, and it is said that trained elephants do this with the same precision as dock labourers and with greater rapidity. In clearing the ground of bushes and undergrowth, too, they are exceedingly valuable, and they played an important part in making many of the tea plantations of India.

XIV

THE STORY OF THE OTTER

AS another illustration of the ways of mammals let us take the otter (*Lutra vulgaris*). It is still fairly common in Somerset and Devon and the Lake District in England, and is also found in some parts of Wales, Scotland, and Ireland. It has a near relative in Canada and the United States. The wonder is that it holds its own as well as it does, for man's hand is strongly against it because of its fine fur. It is a very ancient inhabitant of Britain, for its remains are found as *fossils* in what are called later Tertiary deposits before the Great Ice Ages.

The otter is one of the Carnivores, and it belongs to the "Bear tribe," along with stoat and weasel, pole-cat and badger. But it differs from all these in having become aquatic. It has not gone so far in that direction as seals have, and not nearly so far as porpoises, which have become independent of the land altogether, but it has become thoroughly at home in the water. In the north of Britain it often lives in caves by the sea, and it may swim out to islands far off the coast. But it is not to be confused with the rare Sea-Otter (*Enhydris lutris*), which is now restricted to some islands of the North Pacific. The true Sea-Otter is only a distant relative of the Land-Otters, and it does not come ashore except for short intervals and for breeding.

One of the interesting features in our Land-Otter is that it has become very much at home in the water—both fresh and salt—without losing its efficiency on land. It may travel fifteen miles in a night, and it makes long excursions in search of good fishing.

How is an otter fitted or adapted to life in water? It has webbed feet; the very muscular tail is a strong rudder; it has astonishingly good "wind," and is thus able to remain

for a long time immersed. It is interesting to see an otter entering the water without making a splash, and to see it come out again—almost like a different animal. It looks distinctly smaller, for the glistening outermost layer of wet fur clings closely to the body and compresses the dry under-fur. We see, then, what a muscular animal the otter is; it has fine "stream-lines," like a yacht, well-suited for rapid movement through the water. The otter is an athlete.

It often swims horizontally near the surface, making little in the way of ripple, and then, all of a sudden, it dives, often in a spiral, and reappears with a fish in its mouth. A small fish may be swallowed in the water, but an important capture must be carried ashore or lifted on to a projecting rock. In swimming near the surface the otter uses both fore and hind feet, which are webbed as well as clawed. But in pursuing its prey beneath the surface or in deep diving the fore-limbs are said to be the only parts used, the hind legs being turned backwards in seal-like fashion. As we have mentioned, the broad tail is used as a rudder. Mr. Tregarthen, who has studied this animal all his life, has given us in his *Life Story of the Otter*, an account of its swimming and diving; its games and gambols. This is all the more welcome because most people do not get more than tantalising glimpses of the otter. It is one of those animals that are always disappearing; it effaces itself in a moment. Moreover, it does most of its hunting and roving by night.

In the main a fish-eater, fond of eels, trout, salmon, pike, flatfish, and so forth, the otter has *a long bill of fare*, and that helps an animal to hold its own. If it cannot get one kind of food, it tries another. Thus if the otter cannot catch fish, it condescends to eat mussels on the seashore, biting through their shells. It will even knock limpets off the rocks, and it will crunch up big land-snails. On another line it catches frogs in the marsh, or wild-duck by the lake-side, or rabbits on the links. All is grist that comes to the otter's mill.

The otter has excellent teeth, and the socket in which the lower jaw works is very deep and strong. This gives it a very tenacious grip, well suited for keeping hold of a struggling

eel or pike. Like many another carnivore, the otter is apt to kill more than it needs if a good opportunity occurs. This is not "greed"; it simply means that the inborn impulse to kill is irresistible. It seems to enjoy a draught of blood when its appetite for flesh has been satisfied.



Photo: Frances Pitt.

OTTER CUBS AT BREAKFAST.

The cubs shown are enjoying a delicacy provided for them by their most careful and solicitous mother.

Many carnivores go back to the "kill" which they have left unfinished, but the otter rarely does so. It is not likely that the creature thinks this out; it is more probable that it feels instinctively that danger lies that way. Similarly, it often seems to avoid retracing its steps or making definite tracks. Morevoer, its scent soon disappears when the sun rises.

THE OTTER'S SURVIVAL

Here, then, is a large-sized mammal still keeping its foothold in a very unfriendly country. How does it manage it ? Let us add up what we have said. The otter has reduced both its enemies and its risks by becoming aquatic ; it has lessened them again by becoming nocturnal ; it has strengthened its position by having a varied bill of fare. Then it is endowed with a fine brain, alert senses, splendid muscles, and a very vigorous constitution. Therefore it manages to survive over large areas in Europe and North America, though a big price is put on its head. But we have not yet discovered the whole truth. The otter survives in virtue of two other outstanding qualities : it is a rover, and it shows a high degree of maternal care.

Mr. Tregarthen is right in calling the otter "the homeless hunter," "the Bedouin of the wild." It has not merely one well-hidden shelter or "holt"; it has several. It treks by night from one to another, and they may be ten or twelve miles apart. The otter is very often "from home." "It passes from tarn to stream, from river to shore ; it swims far out to sea and reaches isolated rocks ; it wanders along the cliffs and explores the caves ; it crosses the heather-covered hills and even the mountain-passes, sheltering by day among the thick bracken or in the heart of a cairn ; it neither stores nor hibernates, but is always on the move—a gipsy among carnivores." (Thomson's *Secrets of Animal Life.*)

The otter is full of resources, but its severest trial is a hard and prolonged frost, which seals up the loch and drives wild-fowl away. The defiant creature can hunt underneath the ice if it finds a hole, and it is said to have a wonderful power of returning to where it entered. But this is a very dangerous game to play, for the hole may freeze and the otter be imprisoned. Those that live near the sea are less likely to die of hunger, and it is a fact that when frost binds the land the otter leaves the hill tarns and the smaller moorland streams, and makes his way down to the estuaries, where the salt water

does not freeze, and where, even if the food be coarser and less to its taste it is still plentiful.

Otters usually have one litter in the year, but two are said to be common in the north of Scotland. The births may occur at any season, but midwinter is a frequent time. A "nest" is made away from the usual shelter or "holt"; it may be under an overhanging dry bank, or in a cairn, or inside the stump of an old tree, or in the shelter of a cave.



Photo: Dr. Francis Ward, F.Z.S.

THE OTTER BEGINNING A DIVE.

The otter is an expert fisherman, and loses no chance of securing a catch by unnecessary movement or noise. By means of its long flat tail the creature clings to the surface of a rock and lowers its body stealthily into the water.

The two or three young ones are very helpless at first and grow slowly; they are blind for over a month. What is most striking is the mother's care. She will hardly leave the cubs except to make hasty rushes to find the food necessary to keep up the supply of milk. She sleeps with one ear open. When the young ones can see, she takes them out for a sun-bath, and grooms them carefully. When they are about two months old, she takes them to the water, an experience which they do not seem to enjoy at first.

What Mr. Tregarthen has been able to show so well is that

the mother otter gives her children the benefit of an elaborate education. She teaches them what certain sounds mean; she punishes disobedience and foolhardiness; she gives them swimming lessons till they are expert, and shows them how to lie quiet beneath the bank of the pool with only their nostrils out of water. She instructs them in the quest for food—how to "guddle" for trout and how to catch frogs. She enforces table manners, for the eel must be eaten from the tail-end and the trout from the head, and the frog must be skinned first. All through the prolonged and detailed education, which is perhaps the chief factor in the otter's success, there is a delicious playfulness. Not only are the young ones frolicsome and playful, unconsciously serving an apprenticeship to the serious business of life, but the mother joins in their games as if she thoroughly enjoyed herself. This occurs year after year, and it may be part of the otter's secret for remaining young. "The playsomest creatures on God's earth," the woodman said.

The Canadian otter, which is a near relative of the Old World species, indulges in a toboggan game. They lie down on a slope of hard snow, bend their fore-limbs under their breast, give a kick with their hind legs, and off they go! Then they climb laboriously up again—they cannot move on land so well as our otters do—and repeat the performance, continuing until they are tired. The same steep bank of snow is used over and over again, until a well-marked "chute" or "slide" is formed. It is a great pity that the delightfully playful Canadian otter is becoming rarer every year, and simply because man is over-greedy. The European species is still fairly plentiful in the British Isles, much more so than is commonly imagined.

Before we leave the roving, playful, resourceful otter, we wish to refer again to the rather interesting fact that the young are at first averse to the water. They are ill at ease, and call pitifully for their mother, who does not leave them too long. Sometimes she encourages them by giving them a ride on her back as she swims. This unpreparedness of the young ones for aquatic life is at once intelligible when we remember that they are derived from a terrestrial stock

A GOOD CATCH.



The swimming powers and the agility of the otter make it a formidable enemy of fast-moving salmon and trout. Here one is seen twisting and turning in rapid pursuit of—



Photos : Dr. Francis Ward, F.Z.S.

a large fish which it eventually succeeds in seizing by the head.

that took to the water as a second string to their bow. In the same way we can understand why the mother otter has to teach her offspring to like fish, for flesh was the food of their ancestors. These are simple instances of the way in which the past lives on in the present.

THE STOAT AGAIN

In one and the same place, the golf links at Balgownie, near Aberdeen, we got three interesting glimpses of the life of the Stoat—a common British carnivore previously described. They form a good illustration of the ways of big-brained mammals just because they are not extraordinary—any one can " cap " them.

In front of us we saw what looked like a great brown snake, six feet long, wriggling through the wiry grass called " bents." It made us rub our eyes and crane forward. Then we saw that it was a mother stoat with no fewer than seven youngsters in Indian file behind her, the head of one practically touching the tail of another. She was taking them from the bents near the seashore to the rough ground farther inland, from their birthplace to their school. As the procession quickly swung across the fairway of the golf-course, across the valley, and up among the gorse on the other side, it looked, we say, like a long brown snake, and every link in the chain was like a snake, so supple and lithesome are the little creatures. We knew what would have happened if we had been foolish enough to run forward; the mother would have turned on us in defence of her children. But we soon lost sight of them in the " rough."

Another day, as we were approaching a putting green, we saw a circle of small birds, including larks and meadow-pipits, quite still on the grass. We wondered why they were so quiet, so we approached very slowly, and then we saw a strange sight. In the middle of the " gallery " of birds there were two young stoats behaving in an extraordinary way. They were jumping into the air and turning somersaults; they were gambolling; they seemed to us to be making " living wheels " of themselves. The little birds

were standing as if spellbound, preoccupied with the strange behaviour of the stoats. We should not use the word "fascinated," but there may have been some deep-seated dread beneath what looked like amazed interest. But we had to go on, and at the first movement forwards, the stage was empty—birds and stoats had vanished. We know, however, that if we had been able to make ourselves invisible, there would soon have been two birds missing and two stoats well pleased. For it is a device that stoats sometimes employ in catching birds. It is like turning play to a use. The birds are preoccupied—we came quite near them—and their interest is their undoing. Two quick jumps and two birds are instantaneously dead. It is all so quick, that it is sheer nonsense to speak of cruelty. Every creature must die some time.

Another morning, on the same links, as we followed the crooked path of the little white ball, we saw ahead of us a stoat going very slowly. We wondered why it was going at such a sluggish pace, for stoats usually lope along the ground at a great rate. We could not but overtake it, and though we cried "Fore," it did not go any faster. We would not have hurt it for the world, but we had to keep moving, for there were other golfers behind us, and *then we saw.* It was a mother stoat, taking a single young one on its first excursion—a young one of so tender an age that it could not run. Now what did the mother do? She seized her child by the nape of the neck, ran forward quickly, laid it in a bunker, and then came to meet us!

Such were three snap-shot observations of a common animal in one and the same place. They might be extended and deepened, readily enough, by any one who has access to Wild Nature. They were simple observations, yet how "brain-stretching"! How many problems they raise in the inquiring mind. They give us glimpses of *the subtlety of life.*

XV

SOCIAL MAMMALS

THERE are different levels among social mammals, as contrasted with " solitaries " like the badger, the otter, the wild cat, and the fox. First there are those that often live together in large numbers, but have no communal life. This is illustrated by a rabbit warren. It is possible that the large company makes it less easy for rabbits to be taken by surprise when feeding and playing at dusk, but, so far as we know, rabbits never act in common, and there is no posting of sentinels. The same may be said of the prairie-dogs of North America. Numerous individuals live together, because they have found a suitable place and because they multiply rapidly; they are just on the verge of being social, but that is all.

Yet it is impossible to draw a hard and fast line. The late Mr. W. H. Hudson tells us in his charming *Naturalist in La Plata* that the Viscachas of the Pampas have a good deal of " conversation " with one another, and that they have games together. They belong to the order of Gnawing Mammals (or Rodents), and they sometimes do much harm to crops in the neighbourhood of their village. In exasperation, the farmers sometimes pile up earth over the mouths of the burrows so as to bury the viscachas alive. But during the night there comes a band of viscachas from the next village, and the rescuers dig out their neighbours! Whenever there is combination the social note is sounded.

To take another example, of which we have already said something, the Scandinavian lemmings live together in large numbers in suitable places, but they have no communal life. Yet when they are forced by lack of food to go on the march, they combine in a great army, and in this combination there is the beginning of social behaviour.

The second level is that illustrated by herds of deer, antelope, wild cattle, and the like. Here the advance is to be seen in *combined action*. The herd moves as a whole; the members unite their forces against a common enemy. Thus the little shaggy dark brown musk-oxen of the Far North in Canada retire before the pack of wolves till they reach a height or the foot of a cliff, where they form a circle or a semi-circle with the calves in shelter and an array of formidable horns fronting the foe. What the musk-oxen do for defence the wolves do for attack, and there is sound Natural History in what we read in Kipling's *Jungle Books*, about the laws of the pack. There is team work, and the pack is able to surround a small flock or to overcome a formidable enemy just because the members play the game and do not work each on his own. In herds there is often a posting of sentinels and the use of danger signals. In many cases, as in reindeer, there is a periodic mass-movement or migration from summer quarters to winter quarters and back again, and this is on a higher level than the occasional trekking of large numbers of rats or lemmings.

The third level among social creatures is well illustrated by the beaver village, which is nearer to the "hive" than to the "herd." For beavers combine in common enterprises, such as building a dam or cutting a canal; and their story is so interesting that we must give it room by itself.

THE BEAVER

The Beaver is one of the Gnawing Mammals or Rodents, and has squirrels as its near relatives. It cannot be said to belong to a clever race, and we suspect that most of the admirable things it does are the outcome of inborn instinct, not of lessons which it has intelligently learned.

It used to be a native of Britain, and there are traces of its industry ("beaver meadows") still recognisable in some parts of the country. But it is long since gone from Britain, and in Europe it lingers only in very secluded corners. Even in North America, where it used to be very abundant—for the American beaver is almost the same as

Photo: New York Zoological Society.

A BEAVER'S HOUSE OR LODGE.

Though not possessing the intelligence displayed by dogs or monkeys, this rodent has remarkable instincts and achieves very striking results by co-operation. The illustration shows a beaver lodge—a rough structure of sticks and mud, divided into two compartments, the living-room and the store.

the European one—it is becoming more and more restricted. It is being pushed farther and farther westward. The fact is that its fur is all too dangerously good, and in spite of its shrewdness and social habits, the beaver is not holding its own. Its relationship to squirrels is rather interesting, for both of them have more or less left their original headquarters—the solid earth—and found out new homes. The most thoroughgoing squirrels have become tree-mammals ; the beaver has taken to the water.

It is suited for life in the water in having thick, waterproof fur, in having webbed hind feet, and in having a strong, flat, scaly tail, which is used as a rudder in swimming. The old mistake dies hard, that the beaver uses its flat tail to plaster down the clay that forms part of the dam. But that is one of the things the beaver does *not* do. In the summer months beavers often roam about for considerable distances, enjoying abundant food, but the heavy, rounded body and the short legs are not well suited for trotting about on land.

Beavers have many safety-giving qualities, and they would be prosperous still if man had not attached so much value to their thick, silky under-fur. Formerly beaver fur was used in the making of top-hats, but since silk was substituted in this manufacture, the beaver is gradually returning to its old haunts. The animal is protected by law in most States of the American Union, trappers being restricted to so many pelts during the season. Beavers find safety in their powers of swimming and diving, and in their habit of storing twigs and pieces of branch ; there is safety in their nocturnal habits and in having a long bill of fare, for they can eat many different kinds of vegetable food ; but, most of all, there is safety in the way they help one another and in their inborn efficiency.

There is first of all the business of felling trees, which are often up to sixteen inches or so in diameter. With the chisel-edged front teeth the beaver cuts two parallel furrows *across* the grain of the wood, and then wrenches off the part between in a succession of chips. It then makes another parallel line, and gouges off another circle of chips. It goes

on doing this till a biconical or hour-glass-like excavation has been made all round the tree, which then falls. A careful observer records a case where a cotton-wood tree nearly thirty inches in diameter was felled so skilfully that it tumbled with its top right into the middle of a small beaver-pond, thus assuring abundance of food for the animals at their very door. But this was probably more through luck than good guidance, for things do not often turn out so well. In many cases the tree falls the wrong way. The tree chosen for cutting is often at a considerable distance from the lodge, so that it does not matter much how it falls. Moreover, beavers seem often to tire of a tree and leave their work half done, it being a common feature in instinctive activity, that if there is a bad interruption, the work is abandoned. It seems that we must give up the story of the beaver-woodmen cutting their tree unequally so that it must fall to the most convenient side, and the other story of the beavers intentionally leaving a tree half cut through, so that the rest of the felling might be done by the next gale! Beavers are wonderful enough without these yarns. The tree they like is one under a foot in diameter, and the meaning of the felling is to bring many sappy branches within easy reach.

Another line of activity is making the pond and its dam. The use of the pond is to have fairly deep water round the lodge, so that the beavers can swim underneath the ice in the winter. The depth of the water secures an open under-water door, and the depth is secured by the dam. This is an entanglement of driftwood, willow branches, and the like, strengthened by mud and stones, which the beavers carry in their hands pressed against their breast. The branches and twigs are carried in the mouth. Streams of considerable breadth are sometimes dammed, but this is exceptional. It is said that the barrier is built straight across when there is almost no current, but with a convexity directed up-stream when there is a considerable flow. But it is possible that this up-stream curve may be explained mechanically without crediting the builders too generously with wits. It must be remembered, also, that after a flood

there is often in a narrow stream a blockage due to driftwood, and that this barrier naturally forms where it is most difficult for it to be carried away. Such a natural and temporary dam might well be the beginning of the beavers' artificial and permanent dam. For animals are more likely to adapt than to invent.

There are other interesting points about the beavers' dam, such as the way in which some of the branches may begin to grow into rooted bushes, thus strengthening the construction and hiding it in green in the summer. But the most interesting thing to us is that many beavers may combine in their enterprise, which benefits many lodges, not only one.

Two kinds of houses are made by beavers, and there are many intermediate forms. In rivers like the Colorado, with high banks and a changeable water-level, the beavers make a tunnel well under water, and this leads to a large burrow in the bank. That is all the house there is; but in other cases the beavers make a "lodge." This is a roughly constructed, conical erection of sticks and mud, several feet high, eight to ten feet across the base. The door is usually under water, but there may be two doors, one on the ground, the other in the pool. Part of the interior of the lodge is a living-room and bedroom, the rest is a store of cut twigs and branches laid up for the severe winter.

In some cases great bundles of twigs and branches are stored near the door of the house on the floor of the beaver-pond, being weighted down with stones. If this is all correct, it certainly smacks of intelligence. Another interesting point is that in the autumn extra mud is often pressed on the outside of the hut. When this is frozen hard in winter it forms a comfort-bringing wall, keeping out the terrific cold. But more than that, it is a rampart against the intrusions of hungry wolves and wolverines. It is a pity that fanciful pictures have often been drawn of the beaver's lodge, for it is rough-and-ready architecture at the best, not to be compared for a moment to such masterpieces as the wasps' nest or the white ants' termitary.

Beavers are not only gregarious, they are sociable ; they are not only sociable, they are co-operative. This is well illustrated by the dam-making, and equally well by the canal-cutting. Many lodges, built around a big beaver-pond, make a beaver-village ; and when a beaver-village is well-established for years and years there must be a gradual reduction in the number of available trees. Those nearest the pond will be used first, but in the course of time little journeys will have to be made, just as the trawling vessels of a fishing-port have gradually to take longer and longer voyages. But the beavers have to carry the cut pieces of branches in their mouth, sticking out on each side, and while this is easy enough when the animals are swimming, it is bound to be tedious when they are making their way through the undergrowth of a wood. No doubt they make paths, but there is something better than a path, namely, a canal. The best of these canals are very remarkable. They may be several hundred feet in length. They may make a short-cut between one bend of a snaky stream and another. They may cut right through an island. If we think of the last case, we see we are face to face with a rather remarkable enterprise. Making a long canal is a task which cannot be accomplished by the individual beaver ; it must be tackled co-operatively. More than that, if we understand the situation rightly, as shown in an interesting photograph by the Duke of Argyll, the co-operative work would not have much point until it was completed, with an open waterway right through. This looks like working towards an end—however dimly descried. At the same time we all know that in a low wood, by the side of a river, a pathway may readily become, in times of heavy rainfall or flood, a sort of natural canal. Perhaps in some such paths, naturally turned into waterways, beavers found a hint that they improved on. For, as we have said, animals are more ready to adapt than to invent.

The beavers live together in pairs, keeping true (monogamous). There is a long youthful period, and the family relations seem to be very pleasant. When the beaver-village gets over-full, there has to be a search for new ground,

and some observers say that the flitting is on the part of the grandfathers and grandmothers—the old and the bold—but we cannot vouch for this.

We do not think that the beaver is a *clever* mammal, to be compared, for instance, to the fox, stoat, horse, or elephant; but it has the co-operative temperament, an ability to work with others, which is one of the greatest of gifts. It has had, in the course of ages, wits enough to test promptings and suggestions arising from within, and to hold fast to that which proved good. We do not mean that any beaver ever had any idea of a dam and its advantages. We mean that when there were suggestions in the direction of dam-making—partly from the consequences of river-floods, partly from new departures on the creature's part—the beavers tested these and somehow held on to what proved good.

XVI

THE WAYS OF MAMMALIAN MOTHERS

MOTHERING is so prominent among mammals that we cannot leave it out of our study of their ways. It may be mentioned that the very name mammal refers to the breasts of the mother (*mamma*, a teat).

EGG-LAYING MAMMALS

Long ago the natives of Australia reported that they knew of a furred creature—the duckmole or duck-billed Platypus—that laid eggs. But zoologists knew better; they were sure that no mammal could lay eggs. Yet the natives were right. There are two kinds of Australian mammals which resemble birds and many reptiles in being egg-layers or oviparous. They are the most primitive or old-fashioned of all mammals. The duckmole or Platypus is a close-furred squat animal, rather over a foot in length, with a bill like a duck's, and feet that are webbed as well as clawed. It lives in ponds and slow-flowing reaches of rivers, grubbing in the mud for molluscs and other small fry, collecting a lot in its mouth and chewing them afterwards at its leisure. It has true, hard teeth to begin with, but they do not last for more than a year, after which they are replaced by horny plates, which make good crushing instruments. The duckmole is imperfectly warm-blooded, and one may detect a number of reptilian characters, lurking, as it were, in the recesses of its body. It lays two eggs in the end of its burrow beside the water-pool. The egg has a white membranous shell, and may be over half an inch long, whereas a common size for a mammalian egg-cell or ovum is $\frac{1}{125}$th of an inch. What makes the egg of the the duckmole large is the yolk, which is practically absent

from the egg-cells of ordinary mammals. To put it shortly, the egg of the duckmole is very like a reptile's egg. When the young one is hatched, it licks a patch on the under surface of its mother's body, where the milk oozes out by numerous openings. Since there is no teat or mamma for the young one to suck, the duckmole is not in the literal sense a "mammal," but it would be very pedantic to refuse it the title.

The Spiny Ant-Eater or Echidna is a terrestrial animal, about a foot in length, powerfully built, with many hairs transformed into strong spines. It can burrow quickly, sinking into the ground so that the last part seen is the ridge of the back. It has a long, slender snout, and out of the toothless mouth comes a slender, glutinous tongue, which is very useful in catching ants. Like the duckmole, the spiny ant-eater is imperfectly warm-blooded, and its temperature may change several degrees in a few minutes. When winter comes the creature falls into a state of hibernation in a confined space.

The egg is like that of the duckmole, but when it is laid the mother takes it in her mouth and places it in a forward opening pocket on the ventral surface, where it undergoes development. The milk-glands open on the side-walls of the pocket, which some zoologists regard as a greatly expanded and hollowed-out teat. It disappears when the breeding season is over. It is interesting to notice that the "milk" of the spiny ant-eater is very different from ordinary milk. It is very rich in proteins or white-of-egg substances; it has little or no sugar; it has no phosphate salts. The young one probably licks the inside of the pocket, where this strange milk exudes.

POUCHED MAMMALS

The second step on the mammalian ladder is occupied by the Marsupials, in most of which the females have an external skin pocket for the shelter and nurture of the young ones. Kangaroos, bandicoots, phalangers, wombats, Tasmanian devils, are all marsupials. They were once widely distributed,

for their fossil remains are found even in England, but it seems that they had to give way before other mammals with better brains. So it has come about that apart from the American opossums and the rare selvas from the mountains of Colombia and Ecuador, all the present-day marsupials are Australasian. They have that island continent almost entirely to themselves, as far as higher mammals go, for a geological subsidence very long ago separated Australia from the Asiatic continent before the marsupials had been followed by formidable rivals. In Australia the marsupials have evolved along many different lines, curiously suggestive of several of the orders of higher mammals. There are herbivorous kangaroos and carnivorous thylacines; there is the rodent-like wombat and a remarkable burrower, Notoryctes, superficially like a mole. There are several parachutists, whose webs of skin present a strong resemblance to those of the flying squirrels among rodents.

Now, one of the many peculiarities of marsupials is that the young ones are born very ill-developed—as it were, prematurely.

In ordinary mammals, such as sheep and cattle, cats and dogs, rats and rabbits, the unborn young one is very closely bound to its mother's womb, so that it is a sort of partner with its mother for a long time before birth. The organ that binds the unborn young mammal to its mother is called the placenta or after-birth. Except in one case (a bandicoot-rat, called Perameles), there is among marsupials little hint of a true placenta, and the connection between the unborn young one and its mother is less thorough. But there is more than that. A pony mare carries her foal before birth eleven months, whereas a large kangaroo, the same size as the pony, brings forth its young one thirty-nine days after its (ante-natal) life began. This new-born kangaroo is blind and naked, and only an inch long. In a remarkable way, unhelped by its mother, it creeps along the skin to the pouch. Here it gets its mouth over a teat, which then expands a little and gives the baby a grip. But although the mouth is suited for holding on, the young marsupial cannot suck. So the mother has to force the milk into its mouth by the

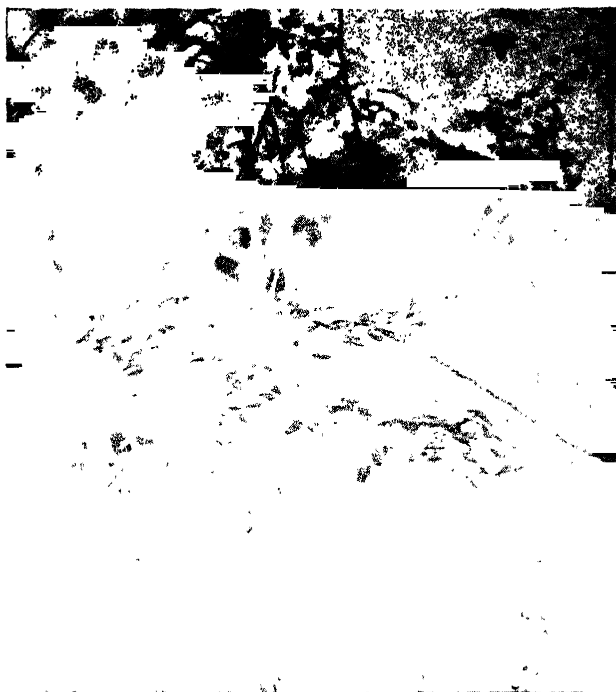


Photo: W. S. Berridge, F.Z.S.

THE URSINE TREE-KANGAROO.

Although, as its name implies, this species of marsupial lives in the trees, it is a clumsy climber. This is outweighed to some extent by its remarkable jumping powers and tenacity of grip. An inhabitant of New Guinea, it feeds on fruit and ferns. In many cases the family keeps more or less to one tree. It has probably become arboreal within comparatively recent times.

contraction of a special muscle. The milk would be apt to "go down the wrong way" and choke the baby were it not that the opening to the windpipe (the glottis, it is called) is shunted forwards into the back opening of the nasal chamber. Thus air gets right down to the lungs, but no milk goes the wrong way. It is very interesting to find a similar adaptation in a whalebone whale, for when it is rushing through the water with its mouth agape, the glottis

is pushed forward into the back opening of the nasal chamber (the "posterior nares"). The front nostrils or blowholes ("anterior nares") are at the same time closed by valves, and for these two reasons taken together no water gets down to the whale's lungs.

After a period of development in the pouch, the young marsupial becomes able to stick its head out. It is a quaint sight, when the youngster pops out its head and looks round! By and by it jumps out and begins to fend for itself; but when danger threatens it returns to its safe cradle. The hopping out and in is very extraordinary.

In a minority of marsupials there is no pouch, and then the young ones hang on to their mother's fur, sometimes helped by having their tails twisted round hers. This is also the habit of the young of some of the pouched kinds; they hang on to their mother after they have left the pouch for good. Azara's opossum, a pouchless marsupial about the size of a cat, is said to climb trees very effectively while carrying eleven rat-sized young ones on her back. And they do not even intertwine tails. We see, then, that while these marsupials are behind ordinary mammals in the connection between young ones and mother *before* birth, they have an unusually close and prolonged partnership *after* birth. It is hardly necessary to say that the pouch or marsupium is confined to the females.

There is a very dainty marsupial in Queensland and New South Wales, called the Pigmy Aeroplaner (*Acrobates pygmæus*), which is not so big as a mouse. It has a web of skin drawn out from the sides of the body between the fore and hind limbs, and this is used in gliding from branch to branch. The pigmy mother has only four teats in her pouch or marsupium, but there are far more young ones. This leads to a serious difficulty. When the young one is born it is almost incredibly small—it is not longer than the breadth of our little finger nail. It crawls up the body of the mother, hanging on to the hair, and if it reaches the pouch in time it is safe. But as the pouch will not accommodate more than four, only the first four can survive. The others die in a very short time—a few minutes!



Photo : Underwood Press Service.

THE GREAT GREY KANGAROO.

The figure shows a famous kangaroo in the Melbourne Zoological Gardens. Its wild relatives in Australia are very formidable, both to men and dogs, when at bay. They seize their enemy in their arms and use the powerful claws of their feet with deadly effect.

It seems to be a common thing among small marsupials that more are born than can survive; a number are only born to die. One might think that the young ones could change about inside the pouch, for we see big animals with more offspring than there are teats for. Thus the wart-hog has six to eight in a litter, and only four teats. But the difficulty with the small marsupials is that when one has got its mouth over a teat, it does not let go for weeks. In some cases at least, it *cannot* let go until it is able to leave the pouch.

What can one say of a case like that of the Pigmy Aeroplaner, where one has to face what looks like a serious mistake? There are two things to be said: first, that all arrangements among animals are not equally perfect and that some adaptations are still in process of being adjusted; and, second, that when it is difficult for the very fragile and very partially developed young one to get into the pouch, a margin must be left for safety. Those pigmies have survived that have a wide enough margin as regards number of offspring.

PLACENTAL MAMMALS

In all the ordinary mammals that we are familiar with—monkeys and apes, carnivores like the lion, insectivores like the hedgehog, rodents like the hare, hoofed animals like horses and cattle, and more divergent forms like sloths and ant-eaters, cetaceans, sea-cows, and bats—there is a complex organ, already named as the placenta, binding the unborn young one to the womb of its mother. The vital connection is so closely knit that we must use some word like partnership. For while no solid particles can pass from the mother to the unborn offspring, the dissolved food in the blood of the mother must filter through into the blood-vessels of her young one; and there must also be diffusion the other way. The mother contributes soluble food, oxygen, and those invaluable chemical messengers called hormones. The offspring returns nitrogenous waste, carbonic acid gas, and also hormones. For they say that the unborn offspring does in some measure reward the mother for her sacrifice by

contributing chemical messengers, which seem to help her to make the most of her own food.

We have used the word sacrifice in connection with these mammalian mothers, for we must think of a case like the elephant, where the mother carries the young one before birth for twenty-two months, and where she contributes enough of fluid food to build up a young elephant which is already about a yard high when it is born. The building materials for such a large baby must mean a large sacrifice of the mother's food, but the sacrifice is, of course, quite unconsciously made.

There are great differences in the length of the sleep before birth, and the general statement may be made that the longer it lasts the more developed will be the brain and the body architecture of the young one when it is born. The big-brained, clever mammals usually require a long sleep before birth. Thus a monkey's young one may be carried for seven months before birth, whereas young rats are carried for only three weeks or so. But there is another thing to be thought of in this connection. When the mother has a well-hidden den or nest, or when she carries the baby or the babies about after birth, it is quite safe for the young ones to be born very helpless, and they are often blind and naked. Every one knows the helplessness of young kittens and young rabbits. There are advantages in the prolongation of this period of helpless infancy, so very marked in mankind, for it secures a long sheltered time during which the body and brain can grow in gradually expanding surroundings; and it must also tighten the bonds of affection between parents and offspring.

There are other conditions of life, however, where it is necessary that the newly born young one should be on the spot almost at once, because the situation is full of danger. So just as there are some newly hatched birds, such as plovers, which are able to run about the very first day, so there are precocious young mammals, such as foals and lambs, which can move about almost at once. In natural conditions, such as those of wild asses on the steppes, it is necessary that the foal should be able to follow its mother

in a very short time. We are not surprised, therefore, that the mare should carry its young one before birth for eleven months. It is interesting to notice that the foal takes only a short drink of milk, for it is a mover-on; whereas the calf, which is hidden by its mother in the thicket, takes a large drink all at once.

Similarly, as a young whale is born in the open sea, we can understand why it is a much more wide-awake creature than the young seal, which is born on the shore, and would drown if it fell into the water too soon. We are not surprised that the mother-whale should carry its young one for a whole year before it is born; whereas a rabbit, with its young ones born in a safe burrow, carries its young ones only a month before birth.

In some of the tribes of Central Africa the mother carries the young child on her back or on her side all the day long. As she works in the field, or milks the cows, or goes about the hut, she has the baby always with her, and the child often clutches hard. Similarly, the mother monkey often carries her child from tree to tree, and the father sometimes gives her a rest by taking his turn. We have spoken already of certain marsupials that sometimes climb or even swoop with their babies on their back or in their pouch, but still more daring is the mother-bat, who flies in mid-air with her offspring clutching her breast with its thumbs, and closing its tiny front teeth on the curiously roughened hair. It is hardly necessary to say that a bat has very rarely more than one offspring at a time. One is enough for a flying mother to carry about, and the small number also indicates plainly that bats are very safe in the struggle for existence.

The hippopotamus-mother sometimes carries her youngster astride her neck in the water, and the same is true on land of the South American Capybara, the largest of living rodents, that stands as high as a sheep. The mother sea-cow or dugong is believed to have given origin to some of the mermaid stories, for she uses her flipper to press her baby to her breast.

There is a curious performance in the case of the great elephant-seal. The young one is born on shore, but after it

has had a good meal it shuffles down to the sea, for which it is not yet ready. The mother accompanies it and rescues it from drowning, driving it ashore. But this plunge after the meal seems to be essential to the young one's health.

Among deer it is not difficult to find cases where the young one is unable to move about for several days after birth. In these cases the mother hides her offspring in a thicket,

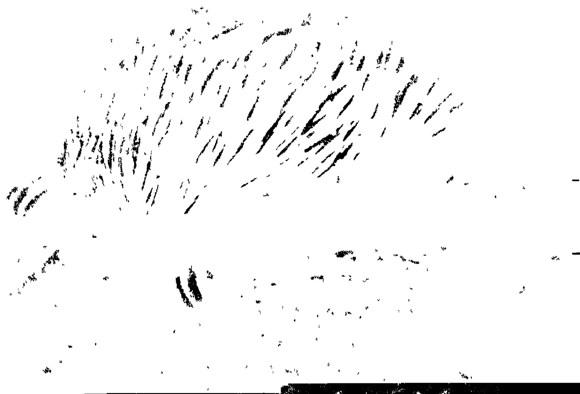


Photo: W. S. Berridge, F.Z.S.

THE ECHIDNA OR PORCUPINE ANT-EATER.

This animal represents the lowest order of mammals, sharing with the duck-billed platypus the peculiarity of laying eggs instead of bringing forth living young ones. It has a long worm-like tongue, which is well adapated for catching the ants on which it feeds.

and this is half-way to a nest! But true nests, so characteristic of birds, are not unknown among mammals. The tiny harvest-mouse weaves the leaves together and hangs its hammock from the swaying wheat. Even the rabbit pulls some fur off to make a bed for the young ones at the far end of the burrow. Amongst the branches of the tree, or where the main stem forks, the squirrel makes a large nest of moss and twigs, and there the young are

nurtured. The nest is often conspicuous, for the squirrel has few enemies. It might be said that the squirrel's nest differs from a bird's nest since the mother squirrel does not *brood*, but that is a distinction without much difference, since there are long, quiet times of suckling the young. Should danger be very pressing, in the shape of a woodman, let us say, the mother-squirrel may shift her two or three babies, carrying one at a time in her mouth.

Many are the instances of the devoted mother-mammal, who will defend her young ones at the risk of her own life, and every one has heard of the rage of the she-bear bereft of her whelps. The finest of all expressions of maternal care, we think, are seen when the mother, as we noticed in the case of the otter, gives her offspring a patient and pains-taking education in all the ways of woodcraft in which they should go.

STORY OF OPOSSUMS

As already mentioned, the marsupials were once wide-spread in America and in Europe, but nowadays they are, with the exception of the American opossums and the little-known mouse-like selvas of Ecuador and Colombia, restricted to Australasia. The selvas are primitive creatures, the sole survivors of a family which once had many representatives. They might be metaphorically called "living fossils." Had they not learned to live in a very quiet way in secluded parts, they would long since have suffered the fate of most of their kindred. For, with the exception of the arboreal opossums, marsupials have usually gone to the wall before the better-endowed higher mammals, and only those were saved which had established themselves in Australia before that great continent became an island, and before the higher mammals had been able to reach that region. Australia was once connected with the Asiatic continent by a great land-bridge extending across the Java Sea. The marsupials were saved by insulation, and in the absence of formidable rivals they flourished in Australia and evolved many different types—some herbivorous, some carnivorous, some like rodents, some like insect-eaters.

There are over a score of different kinds of opossums in South America, but the only North American representative is the Virginian species that extends from New York to Florida and holds its own in spite of terrible persecution. We read that in 1911 a London house dealt with over a million opossum skins, which are much sought after for the sake of the woolly under-fur. We may wonder how the opossum manages to survive, especially since its flesh is palatable, and forms a favourite dish all through the southern States.

The Virginian opossum is a small animal, with a head-and-body length of fifteen inches, and a naked white tail about a foot long. This tail is of great importance in everyday life, for it is as prehensile as a monkey's, and is of great value in climbing. Getting off the ground always means some security, but the opossum has not given up its terrestrial footing. It can burrow as well as climb, and it sometimes gets so far under the base of a tree that it cannot be dug out. Another quality of great value in the struggle for existence is the wide range of the opossum's appetite. It can make a meal of fruits or roots, of nuts and green corn, of grubs and eggs, of young birds and young mammals. It thrives so well on its varied fare that it lays up underneath its skin a store of fat, which keeps it going in the depth of winter.

The familiar phrase, "playing 'possum," refers to the opossum's device of "feigning death" when in a tight corner. Engrained in many animals is the tendency to become motionless when there is a sudden change in the external conditions of life. They pass into a cataleptic state of rigidity, and this is sometimes life-saving, for there are many predatory animals that will not seize anything that is not moving. Somewhat higher in the scale, probably, is the tendency that some animals have to pass into a state of "animal hypnosis." At a critical juncture, when they are rudely shaken, or lifted off their feet, or turned upside down, they become rigid and unresponsive. This may be illustrated from the crab on the shore to the frog in the marsh, and from snakes to poultry. It is not deliberate at all, but an involuntary reaction engrained in the creature's

constitution. It is often life-saving. Somewhat higher still is the opossum's feint, which is also illustrated by a number of much cleverer animals, such as Reynard the Fox. It is not a device that the individual thinks out, but a racial tendency to "lie low and say nothing." There may be something of a faint as well as a feint in it; but there is much to suggest that the self-controlled creature is on the spot for at least a large part of the time—it is so quick to seize an opportunity when its captor has released his grip. Then it pulls itself together and is off!

Although the Virginian opossum is a common animal, it is elusive, and very few naturalists have seen much of its family affairs. But a careful study recently made by Mr. Carl Hartman, of the University of Texas, has dispelled many obscurities. The breeding season begins in Texas in January, and by the middle of February most of the females have young ones in the pouch, which is an external depression of skin surrounding the milk glands. As these young ones in the pocket were born some time before, it follows that the period of development before birth must be very short. It lasts, in fact, only about eleven days, and we cannot be surprised that the new-born opossums are peculiarly helpless. They are born *half finished*, a little over an inch long!

It has for long been a debated point how the young ones got into the external pocket, and several ridiculous ideas on the subject are widespread. A common view, which is not ridiculous, is that the mother takes her new-born offspring—one after another—in her mouth, and puts them into the pocket, fixing them on to the teats. But that is not what Mr. Hartman saw in the Virginian opossum. A young one is born and the mother licks it dry. The baby then proceeds to climb hand over hand into the pouch, where it fixes its mouth on a teat. It certainly reaches its second cradle without the assistance of the mother.

For two months the young opossums enjoy the food and shelter which the pouch affords. For thirty days after that they move freely about on their mother's body, clinging to her hair, and occasionally twisting their tails around hers. When they are startled or hungry they return to the pouch.

Eventually they are weaned, and the mother proceeds after a while to have another family, for there are in most cases two families in the year. There are usually thirteen teats in the pocket, but it is very unusual to find them all occupied. Seven to eleven is a common size for a family, but in rare

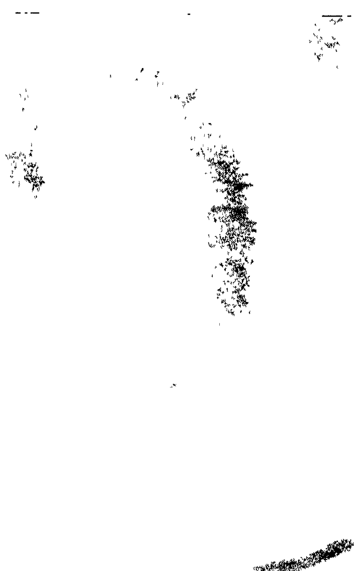


Photo: W. S. Berridge, F.Z.S.

AZARA'S OPOSSUM (*Didelphys azaræ*).

A South American species, Azara's opossum is smaller than its Virginian relative but has a much longer tail.

cases there are over thirteen, and then some must die of starvation!

We are now in a better position to understand how the much persecuted opossum holds its own. To the other reasons already given there must be added this supreme one, that the mother opossum is generously maternal, not only in having two large families in the year, but in taking

very good care of her children till they are able to look after themselves.

Looking backwards, but keeping to mammals, we see that the simplest way of providing for the offspring is to have large eggs, that is to say, eggs with a big legacy of nutritive yolk. This method, which is characteristic of birds and reptiles, is seen in the primitive egg-laying or oviparous mammals, the duckmole (Ornithorhynchus), the Porcupine Ant-eater (Echidna) and another Spiny Ant-eater which often gets a special name (Pröechidna or Tachyglossus). All three are Australasian. The duckmole or platypus usually lays two eggs, approaching two-thirds of an inch in length, and provided with a tough shell. In a recess of the burrow the mother lies on or round the laid eggs, whereas the Spiny Ant-eater puts its single egg into an external pocket. The early development of the egg is like that of a reptile's (or bird's) egg, with what is called partial discoidal segmentation of the living matter. The developing embryo lives on the yolk, which it gradually absorbs; and it breathes, like an unhatched chick or crocodile, by means of a membranous sac (the allantois) rich in blood-vessels, which is spread out within the porous egg-shell. Oxygen diffuses in, carbon-dioxide diffuses out. When the time of hatching comes, the young creature breaks the egg-shell, just as a chick does. It is helped by a conical projection on its snout and a so-called "egg-tooth" just behind the middle of the upper lip. What a strange young mammal it is, with ancestral reptilian characters still clinging to it, as it were! It is blind and naked, about two-thirds of an inch long in the duckmole, about half an inch long in the Spiny Ant-eater. It soon begins to lick the milk, and on the strength of this it grows.

Now, if we compare this state of affairs with what happens when a snake buries its eggs in the warm sand and leaves them to their fate, we see that there are two steps of advance. There is the beginning of brooding and there is nurture after birth. It must be noted, however, that brooding is also seen in some reptiles, and that it reaches its climax not in mammals, but in birds.

On the second level of mammalian evolution, that of the pouched mammals or marsupials, the eggs are practically yolkless, but there is an ante-natal union between the unborn young ones and the mother. In most cases, this is a rather rough-and-ready union—by means of the yolkless yolk-sac, the blood-vessels of which come into very intimate association with those of the mother, so that diffusion of fluid food and of gases can take place from the one to the other. In one case, however—the bandicoot, called Perameles—there is a more finished ante-natal linkage by means of a placenta comparable to that of the ordinary mammals. But in all marsupials the young are born very prematurely and peculiarly helpless—unable even to suck. We have seen how this imperfection is compensated for, in most cases, by a continuation of the development within the maternal pouch.

In ordinary mammals, the minute yolkless eggs develop within the womb of the mother, and the embryos are nourished, after some preliminary makeshifts, by means of a complicated placenta which establishes a partnership between the mother and the unborn young. Thus the newly born young ones are often highly developed at birth. But even then the mother's care is only beginning! For there is suckling and protection, and often some education. We see why mammals should be called mammals!

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XVII

BIRDS AND THEIR WAYS

THE two highest classes of backboned animals or Vertebrates are Mammals and Birds, and, as they have evolved along very different lines, it is difficult to say which is the higher. But as man belongs in his bodily structure to the class of Mammals, it is usual to place that class first. Every one will agree, however, that Birds make a good second. In their skeleton and muscles, their senses of sight and hearing, their blood and breathing, they are not behind Mammals.

It is excusable not to recognise just at once that whales and bats are mammals, but every one knows at a glance that a bird is a bird. For birds are *feathered bipeds*, and the definition is better still if we add the two words warm-blooded and egg-laying. Warm-blooded means keeping the same body-temperature day and night, summer and winter, and the only warm-blooded animals are the birds and the mammals. There are five Running Birds with undeveloped wings: the African Ostrich, the American Ostrich, the Emu, the Cassowary, and the Kiwi; all the others have the power of flight, except in rare cases like the Penguins of the Antarctic.

The ways of birds are of peculiar interest because of their mingling of genuine intelligence with well-established instincts; and there must be added a third kind of behaviour, namely, individually acquired habits. For many birds are very quick to learn new ways.

SENSES OF BIRDS

There are two widely open gateways of knowledge among birds: the sense of sight and the sense of hearing. Many

of us have admired the quickness and certainty with which gulls will pick up pieces of biscuit from the foam in the wake of a steamer. Not less striking is the keen way in which a hawk scrutinises a hillside in search of young birds and mammals. From a great height it detects a victim, and descends as a bolt from the blue. It is by sight, not by smell, that the vultures gather to the carcass. One vulture sees the mammal stagger and fall, and descends on it; a second, in the next aerial "preserve," follows the first, and a third the second, so the news spreads through the sky. Longfellow uses this picture in illustrating the way in which misfortunes often follow one another:

"Never stoops the soaring vulture on his quarry in the desert,
On the sick and wounded bison, but another vulture watching
From his high aerial look-out, sees the downward plunge and follows,
And a third pursues the second, coming from the invisible ether,
First a speck and then a vulture, till the air is dark with pinions. . . .
So disasters come not singly."

A good second to the sense of sight in birds is their sense of hearing. The breaking of a twig is enough to send the bird off at full speed, or to make it utter the danger-signal. Every one knows how the quick-eared geese saved the Capitol, detecting something unusual in the sounds of the night. The excellence of the song in many birds must surely imply a very fine sense of hearing.

To those young birds that are hatched at a very advanced stage, able to run about almost at once, as we see, for instance, in chickens, partridges, lapwings, and redshanks, the quick ear means much. They have an instinctive or inborn appreciation of a particular warning cry which their parents utter, and whenever they hear it they crouch and lie motionless. Thus in the case of partridges, the parents utter a peculiar cluck-clucking note, and the young birds squat flat and remain absolutely still. They will do this when two or three hours old; yet if they have been reared by a foster-mother hen they do not pay any attention to what she says, no matter how much anxiety she puts into her call. This shows how discriminating the sense of hearing may be, as we know it is in clever dogs that can

distinguish their master's motor-horn a long way off, and never confuse it with any stranger's unless of the same type. We shall understand "the ways of animals" better if we linger over the partridges for a moment. The young partridges are unfailingly obedient to their parents' call, yet we cannot suppose that they have at first any understanding of what they are doing when they lie motionless. Their nervous and muscular systems are adjusted from their beginning (by "heredity," as we say) to answer back to one particular sound. We must not think of them as "wise" or "clever"; that is not the right way of looking at it. They have a ready-made equipment that works infallibly without any "learning." That is the miracle and mystery of instinct.

As to the other senses, birds are not well equipped. Touch cannot be very keen in a creature that is covered almost all over with feathers, which cease to be living when full-grown. But there is sometimes acute sensitiveness about the bill in those birds that feel their food before or without seeing it. Thus the woodcock probes for earthworms in the moist soil of the wood, and the tip of its bill has a fine equipment of nerve-endings. The same is true of the snipe. These birds feel food which they do not see.

Taste is not greatly developed in birds, for they are much given to bolting their food and hurrying on. It is known, however, that chickens soon learn to avoid unpalatable caterpillars, and hungry ducklings will, after one trial, refuse little foreign frogs with poisonous skins.

Little is known of the sense of smell in birds; indeed, it does not seem to have been proved in more than a dozen cases, including blackbird, magpie, and some nocturnal hunters. Of the other senses—of temperature and pressure and balance—little is known. Some naturalists have thought that migrating birds must have "a magnetic sense"; they find their way with such mysterious success. But all attempts to prove this magnetic sense have failed. We know that migratory birds are able to return to their northern birthplace after wintering in the tropics, but we have not discovered their *method*, and not much is gained by speaking

THE MOORHEN AND ITS NEST.



The moorhen, really mere-hen (*Gallinula chloropus*), makes a substantial nest of inter-woven flags, reeds, rushes and grass, hiding it cleverly under the overhanging bank of the pond or river, where it is safe from foxes and other prowling enemies.



The hen sits close on a clutch of six to ten eggs, which are pale brown, richly mottled with brownish red. The period of incubation is three weeks, and very often two broods are produced in one summer.

THE MOORHEN AND ITS NEST—*continued.*



The male bird seen setting off in search of food. In order not to betray the position of the nest he begins his journey close under the bank, and steals away unseen until at some distance from the home.



The male is most attentive. Here he is seen bringing some of his catch to his sitting mate. The food consists of water insects and their larvæ, as well as the seeds of water plants.

THE MOORHEN AND ITS NEST—*continued.*



By and by the hen may be seen feeding her first hatched chick. They are charming little creatures, with bright red legs and bills, and, like young chickens, able to fend for themselves from the first.



Finally there is some training of the young birds, but the power of swimming and diving is inborn. The principal enemy of young moorhens is the hungry pike, and to its great appetite they frequently fall victim.

of "a sense of direction." To sum up: in the life of birds the senses of sight and hearing count for most.

BIRD BEHAVIOUR

If a boy could ride a bicycle right away the first time he tried, that would be an inborn or instinctive aptitude. Of this kind of gift man shows little, but birds show much. A young coot swims at once when it is tumbled into the water, and this is true of most water-birds. Sometimes they can swim very well, and yet do not seem naturally keen for the water. This is noticeable in the water-ouzel or dipper, a bird allied to the wrens, that has taken to the water as a second string. The young bird seems to need a push or a tumble to awaken the instinct. In some cliff-birds, like guillemots and razor-bills, where the birthplace may be a ledge two or three hundred feet above the sea, the parents have to coax or even force the young bird to take the first plunge. Sometimes they help the young bird down. There may be actual instruction in some cases. Thus the mother Great Crested Grebe takes her young ones on her back for a sail, and then, sinking beneath the water, leaves them gently afloat.

The great difference between the behaviour of a bird and the behaviour of a bee, is that the bird has fewer ready-made (or instinctive) gifts and much greater power of learning. We have mentioned the inborn ability to swim, and the same is generally true of flying and diving, pecking and scratching, crouching and lying low. But we soon come to an end of of the list, and find the young bird *learning*. Thus Professor Lloyd Morgan observed that his chicks, hatched out in the laboratory away from any bird, paid no attention to their own mother's cluck when she was brought outside the door. Later on, when they were thirsty, and willing to drink from a moistened finger-tip, they did not know what water was for, even when they walked through a saucerful. Only when they happened to peck their toes when standing in the dish, did they appreciate water as the thing they wanted. Only then did they raise their bills up

to the sky in the familiar fashion. Later on these unprejudiced youngsters stuffed their crops with red worsted, as if they mistook the pieces for worms. Evidently they were missing their mother's teaching! But the point is that although they made mistakes they did not continue making them. Not more than once or twice did they try the red worsted or the unpalatable caterpillar. They learned with prodigious rapidity.

Professor Lloyd Morgan reared two moorhens (or waterhens) away from their kindred, and watched them almost from hour to hour. They swam right away, "as to the manner born"—in other words, by instinct; but they would not dive, either in a large bath or in a stream, and, of course, diving is somewhat different from swimming. One of these moorhens, when about nine weeks old, was swimming one day in a pool at the bend of a stream in Yorkshire, when a puppy came barking down the bank and made an awkward feint towards the young bird. "In a moment the moorhen dived, disappearing from view and soon partially reappeared, its head just peeping above the water beneath the overhanging bank." This was the first time the bird had dived, and yet its performance was quite perfect. It had no doubt profited by about two months' experience in swimming, but nothing had previously awakened the diving instinct. When the young bird suddenly saw and heard the dog, the trigger was pulled; it was excited, and it did, we think, to some extent appreciate an alarming situation. Intelligence and instinct joined hands, and the young moorhen dived.

In the quiet of the wood one sometimes hears the song-thrush breaking snail shells on its stone anvil, and one sometimes finds the tell-tale evidences of its appetite—a large number of broken shells, just like the heaps that students of prehistoric man call "kitchen-middens." This interesting habit of the thrush, which comes so near using a tool, is it an inborn gift or has it to be learned? The answer is given by Miss Frances Pitt in her *Wild Creatures of Garden and Hedgerow*. To a young thrush which she had brought up by hand, she offered some wood-snails (*Helix nemoralis*), but

he took no interest in them until one put out its head and began to move about. The bird then pecked at its horns, but seemed amazed when the snail retreated within shelter of its shell. This happened over and over again, the bird's inquisitiveness increasing day by day. The thrush often picked a shell up by the lip and let it fall again, but no real progress was made until the sixth day, when the bird seized a snail and beat it on the ground, somewhat in the same way as thrushes do with a big earthworm. At last, on the same day, he picked up a snail and hit the shell repeatedly against a stone. He tried one snail's shell after another, just as if he had made up his mind, and after fifteen minutes' hard work he managed to break one. He had cracked his first shell, and after that all was easy. A tendency to beat things may be inborn in the thrush, but in this case he learned intelligently how to solve a difficult problem.

As is common among backboned animals, birds often show quickness in forming a linkage between some sight or sound and an appropriate action. A moorhen chick for whose delectation Professor Lloyd Morgan used to dig earthworms, soon learned to run to him from some distance whenever he took the spade in hand. We do not need to suppose that the bird said to itself, "He has got hold of the instrument that discovers worms for me," but there was an association formed in the bird's mind between the picture of the spade and a pleasant experience.

It is this power of association that is taken advantage of in training birds to perform little tricks. Sparrows, cowbirds, and even chicks will learn to distinguish clear-cut marks on cards, and will pick out a particular card on getting a certain signal. Speaking of his Indian weaver bird (*Ploceus baya*), Mr. C. H. Donald writes: "His extraordinary intelligence and his natural love for inspecting everything he sees and picking it up in his beak have been taken advantage of to teach him tricks. He is a very apt pupil, and if carefully and kindly taught will, within a week, select a particular number out of many cards and bring it to his master. He will catch a two-anna piece, which has been thrown into a well, before it reaches the water and bring it back. Some of

his tricks seem absolutely incredible, and yet one and all may be taught in a couple of days each. The first and most important step in his training is to teach him that an open hand means food, and that a closed fist does not. Everything hinges on his first mastery of this secret, and the rest is simple." The weaver bird has a fine brain, it is a clever manipulator in nest-making, it is quick in its movements, and its tricks depend on these endowments, along with a rapid power of linking things together in its mind.

Naturalists often test animals with a maze or labyrinth, like the one at Hampton Court, but simpler. It is interesting to know that this examination has been passed by the house-sparrow, the cow-bird, and the pigeon. In the case of a full-grown pigeon the solution remained in the bird's possession for a month at least.

When we watch birds collecting food and dealing with it, or building a nest and rearing their young ones, what is our general picture of their behaviour? In many cases they have, as we have said, inborn gifts or promptings or abilities, which we sum up in the word *instinctive*. We use this adjective to cover not only chains of actions, such as those involved in nest-building, but also simpler pieces of behaviour, such as catching the food in a particular way. But the birds add to this the clevernesses they learn by making trials and mistakes, and linking things together in their mind. A smooth, juicy caterpillar appears on the scene, and the picture gives the signal "Full steam ahead." A hairy caterpillar appears on the scene, and, unless the bird is a cuckoo, the chances are many that the signal will be "Reverse engines." This is the outcome of individual experience. But to these associations there are added the results of parental instruction and of imitation. Finally, there is sometimes genuine intelligence, when the bird puts two and two together and makes a simple judgment.

Many of the ways of birds are minglings of several different kinds of behaviour, and we have tried to show how it is possible to distinguish several different kinds. Let us take an example. Some young woodpeckers show remarkable dexterity in opening fir cones to get at the seeds. This one

might at first sight call instinctive, like the coot's readiness to swim the first time it tries. Or one might put it down to sheer intelligence, to an understanding of the problem. There would be nothing unreasonable in either of these



Photo : F. J. Manly.

INDIAN WEAVER BIRD.

The weaver birds make neatly woven retort-shaped hanging nests of woven grass. The Indian *Ploceus baya* balances its nest with lumps of clay. The weaver birds are of lively intelligence and very quick to learn, as is well shown by the tricks of *Ploceus baya,* often exhibited on the streets of Indian towns.

ways of looking at the young woodpecker's behaviour. Yet neither of the suggestions is quite right. For we find that the parent birds bring their young ones first the seeds themselves, then partly opened cones, and finally cones that have not been touched. There is a gradual process of teaching and learning.

THE STORY OF THE ROOKS

It is generally agreed that the cleverest birds are rooks and parrots, which are well known to be social and talkative. Both have very good brains, and this may have led to their social habits. On the other hand, the relatives of rooks, such as carrion-crows and ravens, have also very fine brains, and have remained solitary. All the European relatives of the rook are solitary except the jackdaws. Perhaps there is some difference in mood between rooks and crows.

Another way of looking at it is this : living together and talking a good deal may have favoured progress in the direction of nimbler wits ; for these things often work round in circles, and it is a great law of progress in the world of life that to him that hath, more shall be given. Let us think of rooks for a little.

It is in February that the story of the rooks begins, for that is the time of courting. The cock-bird struts and bows before the hen, and spreads out his wings and tail ; and, as Gilbert White noticed, " rooks, in the breeding season, attempt sometimes, in the gaiety of their hearts, to sing, but with no great success." The strutting and bowing and " singing " may occur at other seasons, when the rooks are well pleased with the world, but it is most marked during the courtship. An interesting little ceremony is sometimes seen. The male bird brings his desired mate a little present —some titbit or other—which she accepts with thanks if she likes him. Two rooks seem to remain together for life, but there is a courting every year.

Early in March, while it is still very cold, the rooks begin to prepare a nest. Sometimes they use an old one over again, after a thorough spring-cleaning. There is a good deal of disputing over the twigs, and up to a certain stage they steal from one another if they can. But one rook usually mounts guard while the other breaks the twigs from the leafless trees. After a while they exchange duties. To the pliable twigs they add some earth and clay, and the inside of the nest is made comfortable with grass and leaves, hair and wool. There are often a dozen nests on one tree, and as many as thirty have

been counted. If a branch breaks off, or if there is even a hint of such an accident, the rooks leave the tree. It should be noticed that during the nest-building time the rooks go back at night to their roosting-place, which is usually quite apart from the rookery, but this going to and fro stops when the egg-laying begins, towards the end of the month.

There are usually three to five eggs in a nest, and the mother bird sits very close, the male taking a turn now and then. The colour of the eggs in one clutch is often very different from the colour in another, and this diversity, perhaps due to diet, may have to do with the fact that the eggs are so safe that their colour does not matter much. The nests are so conspicuous that it is of little consequence whether the eggs are or are not. From most enemies, we say, the rook's eggs are safe, but a toll is levied by carrion-crows, which are very successful robbers. It seems rather strange that the rooks should allow this, but they are not very good fighters. Perhaps there is some softness in their character that has led them to be social.

After the eggs hatch, the parents have a very busy time, for the young birds have a large appetite. They are fed on grubs and wireworms and other young insects, so at this time of year the rooks do the farmer a good turn. It is said that in early days the father hands over his collection to the mother, who gives it to the young; later on, both parents feed the young directly, but the mother's contributions seem to be most appreciated—why, we do not know.

There is great excitement when the young rooks leave the nest and make their first aerial excursions. And here it may be noticed that rooks often indulge in various kinds of play—gambols and sham-fights and wild chases. In September there is a flitting from the rookery to the roosting-place, where they spend the winter. Or sometimes there is a partial migration to more congenial quarters.

There seems no doubt that rooks have a number of "words," that is to say, different sounds with particular meanings. Between thirty and forty have been distinguished, and we have counted ten at a rookery. One word



Photo: S. Crook.

MALE ROOK FEEDING HIS MATE.

To begin with, the male rook gives over his collection of grubs and the like to his mate, and she gives the surplus to her brood. Later on, he seems to feed the young ones directly, and the hen-bird joins in the collecting. Rooks are monogamous birds.

was uttered when we moved suddenly beneath the trees, and another when a bird went too near his neighbour's nest. There is one word when the rook sinks down upon the nests and another word when it flies clear of the rookery and makes for the fields. There is most talking, perhaps, at the roosting-place, when the business of the summer is over. "A marvellous medley," said Mr. Edmund Selous in his delightful book, *Bird Watchings*, "a wonderful hoarse harmony. Here are shoutings of triumph, chatterings of joy, deep trills of contentment, hoarse yells of derision, deep guttural indignations, moanings, groanings, tauntings, remonstrances, clicks, squeals, sobs, cachinnations, and the whole a most musical murmur. Loud, but a murmur, a wild, noisy, clamorous murmur; but sinking now, softening —a lullaby."

"I never heard so musical a discord, such sweet thunder."

There is much to be said for the rook, and we think he would say the same of us. For he is distinctly philanthropic. From our point of view, in the first place, the rook is very handsome with his glossy black feathers that show blue, purple, violet, and green reflections as the light plays on them. Like most strenuous creatures, the rook has worked-out pleasant curves on its body, just as a yacht has its thought-out stream-lines. There is an artistic point in having a white to grey patch round the base of the bill, for it "sets off" the head. The disappearance of the bristly feathers round the nostrils and on the chin, which occurs after the first birthday, is not directly due, as some Lamarckians assert, to digging or "howking" in the soil after grubs and such like. It is an engrained constitutional peculiarity, and it is exhibited on birds that have had no opportunity of digging. It is a localised hereditary baldness, and a sign of maturity. Even from a distance, one can tell an isolated social rook from the normally solitary crow by this whitish splash round the root of the bill.

In the second place, there is the admirable flight, with its steady strokes as in a well-rowed boat, much more rapid than it seems. We have often timed rooks as they disappeared over a ridge three miles off in a glen, and, unless

there is some optical fallacy, it always came to about a mile in a minute.

But besides ordinary flight, there is extraordinary flight, as when male rooks make nose-dive displays during their courtship. There is often some very pretty aerial gambolling when rooks are in high spirits. It has no meaning beyond play. But there is nothing to surpass the mastery of the air which is to be seen when rooks "shoot" down with half-closed wings on their resting-place or on their rookery.

No doubt the rook is a *sociable* bird. It likes to have its kindred about; it hobnobs with jackdaws; it seems to like to have man as a next-door neighbour, for a great many rookeries are in the vicinity of houses. But while the rook is the most sociable of European birds, it has not taken great steps towards sociality. We mean that, in spite of its gregariousness all the year round, there is little development of communal life. This is illustrated by the way in which the depredations of carrion-crows and other marauders are tolerated. A little organisation on the rooks' part would soon put an end to that sort of thing, which sometimes goes so far that the rookery is deserted! It is doubtful whether rooks really post sentinels, and the rooks' "parliaments" that have been described have probably to do with partial migrations. On rare occasions a rook will stand up to a fight, but we think he is at heart a Quaker—a kindly, good-natured believer in non-resistance. Thus while his relatives, except the daws, are in the main solitaries, it has suited the rook's friendly temperament to become very gregarious. "There is safety in numbers," he says. Moreover, he is fond of talking.

There is a strong case for giving rooks credit for considerable kin-sympathy, for they will often continue flying near one of their number who has been killed or wounded by a gun. Although they dislike the very sight of a gun, the impulse to stay by their comrade is stronger than fear. Another of their virtues we were almost forgetting—their liking for a bath. This is so keen that it is sometimes gratified amongst the snow. Long live the rook!

Before we change the subject, however, let us refer to the rook's near relatives. The rook is technically called *Corvus frugilegus*, and the Carrion Crow is *Corvus corone*, another species of the same genus. The beak of the crow is stouter than that of the rook, and the nostrils are covered with bristle-like feathers, not becoming bare as in a rook that has quite grown up. One must not make too much of the fact that the rook is social and the crow solitary, for a rook may nest away from a rookery and crows sometimes congregate in winter. The two species have different voices. Then there is the Hooded or Grey Crow, *Corvus cornix*, with a conspicuous mantle of grey; but many authorities regard it as not more than a variety or race of the Carrion Crow. The somewhat rare and much larger Raven (*Corvus corax*) and the lively Jackdaw (*Corvus monedula*) are both first cousins of the Rook.

PARROTS

Almost all the members of the Parrot order are very social birds, and as conversational as the rooks. Most of them are tropical, and they have very clear-cut characters, so that every one knows a parrot is a parrot at first glance, though some of the "love-birds" are hardly bigger than sparrows, and the great macaws are three feet long. Among the notable characters we may mention the short, strong bill, with the upper half, movably jointed, protruding beyond the lower and turning down upon it, making a good fruit-opener, also useful in climbing. The tongue is in most cases large and fleshy, and it can be used for gripping food and conveying it to the mouth. The first and fourth toes are turned backwards, the second and third forwards, an arrangement which gives parrots a good grip of the branches. Most of them have a brilliant plumage, and many of them are startling. There are some extraordinary cases, as in Eclectus, where the males are green and the females red. It is the same colouring matter, but the minute structure of the surface of the feathers is different, and that produces the contrast in colour. Parrots frequent

forests and grassy plains, and they are rather strict vegetarians —feeding on buds, fruits, seeds, and juicy leaves. The most remarkable exception is the Kea or Kaka parrot of New Zealand, which has learned in a short time to kill



Photo: James's Press Agency.

AMAZON BLUE FRONTED PARROT.

The blue colour is a good example of structural coloration. It is due to the physical structure of the feathers. This gives a blue sheen to a dark pigment that is not in itself blue.

sheep by tearing off the fleece above the kidneys and gouging out the flesh.

Most parrots have a harsh voice, but their excellence is in their imitative power, which varies with the kind and with the individual, and bears some relation to cleverness. What parrots say often suggests keener wits than they actually possess, for they are trained to utter words and sentences

that are particularly to the point in certain situations. A great English ornithologist, the late Mr. Bowdler Sharpe, of the British Museum, vouched for the following tale, which is well known. "A friend in Manchester told the writer of a parrot-show in the north of England where the talking powers of each bird were made the subject of a prize competition. Several of the birds had exhibited their powers, and at last the cover was removed from the cage of a grey parrot, who at once exclaimed, on seeing the company to which he was suddenly introduced, 'By Jove! what a lot of parrots,' an observation which gained him the prize at once."

A grey parrot belonging to an English lady living in Florida showed a keen sense of humour. There were three dogs on the place, each belonging to a different owner. The parrot quite on his own account learned the various whistles which would call these dogs, and would utter each in turn. When the dogs came racing up to the veranda where the parrot's cage hung, the bird would fling up its head and utter shrieks of laughter, which was continued while the disappointed dogs slunk away. It was very noticeable that the parrot did not try this trick too often, but only once, or at most twice, in a day. A caller once gave this bird a match which, on being bitten, burst into flame. The parrot never forgot or forgave, and months later managed to give the practical joker a severe bite.

Parrots have a great many interesting ways, and we can give only a few illustrations. As Mr. Beebe says in his facisnating book, *The Bird*, the feet and toes of parrots come near human hands in the variety of ways in which they can be used—for climbing, for gripping the branch, for holding food to the mouth, for prodding their neighbours, and for preening their own plumage. But they are not good for walking purposes. When a parrot is on the ground and in a hurry to get at something, it waddles awkwardly and often trips up. Then the wings fly out and the bird helps itself along *on all fours*, just like its long-lost reptile ancestor!

Like owls and woodpeckers, to which they seem to be

related, parrots lay their eggs in holes in trees. As is usual in such cases, the eggs are white, and we are not surprised to find that in the larger kinds there are seldom more than two or three, for the holes are very safe and the parents guard them. So it is seldom necessary to have a large family. It is interesting that the parrakeets, which are much smaller than ordinary parrots, should sometimes lay a dozen eggs, for they are not in a position to defend them so effectively, and a larger margin is required.

Parrots are emphatically lively birds, full of feeling. Professor J. S. Kingsley speaks of the quick changefulness



Photo: James's Press Agency.

LEADBEATER'S COCKATOO.

Cockatoos form a family of parrots, mostly restricted to the East Indian Archipelago, Papua and Australia. Most of them are marked by a crown or crest of feathers which can be erected when the birds are excited.

of the cockatoos in a zoological garden. "At one moment they are climbing about quietly, using both beak and feet in the operation ; the next instant they are all excitement, every feather is raised, and the crest is expanded and shut with considerable rapidity. Instead of the soft 'cockatoo,' which they were saying a moment before, they are yelling and screeching in a manner indicative of great passion. The cause of the anger, if anger it be, is usually some inconsiderable trifle, or possibly some person whose appearance or adornment does not suit them."

In many cases parrots show great playfulness. This is well marked in the New Zealand owl-parrot or kakapo (*Stringops*), which has taken to burrowing, and has lost the keel on its breastbone which every flying bird should have. Mr. A. G. Sale writes : "Its playfulness is remarkable. It will run from a corner of the room, seize my hand with claws and beak, and tumble over and over with it, exactly like a kitten, and then rush back to be invited to a fresh attack." It is credited with a sense of humour, for it shams great anger at a cat or dog, and then shows great glee.

WAYS OF WOODPECKERS

As a further illustration of the ways of birds, let us fix our attention on woodpeckers, of which there are a good many different kinds. In some countries, like North America and well-wooded parts of the Continent of Europe, they are familiar birds. But even when one hears them hammering all round, one cannot always detect them, even when one scrutinises the *under* sides of the branches. They are elusive birds, always on the other side of the tree !

The most outstanding fact about woodpeckers is that they are so well adapted for arboreal life. The strong-clawed toes are disposed in an unusual way, two forward (the second and third) and two backward (the first and fourth). This arrangement occurs also in cuckoos, owls, and parrots, and must have been evolved several times independently. Its significance is in securing a strong spreading grip, and this, in the case of woodpeckers, makes



GREAT SPOTTED WOODPECKER.

This shy bird (*Dryobates major*) is distributed throughout Europe and Northern Asia. It is marked by a large white shoulder patch and by crimson on its under surface posteriorly. It has a call-note and an alarm-note, but no song. Both sexes signal by drumming with the bill on a stem or branch.

it safe for the bird to go up the tree stem in a series of jumps, and makes it easy to hold tight during the energetic hammering. Yet we must not overbend the bow, for there are three-toed woodpeckers, both in Europe and America, which flourish bravely. Another adaptive feature is the strength of the main tail-feathers, most of which have stiff



GREEN WOODPECKER (*Picus viridis*).

Widely distributed in Europe and Asia, not uncommon in England and Wales, but rare in Scotland. In full light it is very conspicuous with its green plumage and crimson crown.

shafts and hard webs. When the woodpecker is hammering, the points of the tail-feathers are pressed against the inequalities of the bark, and this must make it easier to hold tight. The ploughshare bone on which the tail-feathers are based is unusually broad, which is as it should be. Then there is the density and pickaxe shape of the beak, well suited for woodwork; and in correlation with this is the

strength of the skull-bones. It must be kept in mind that all birds have surrendered their hand to making a wing, so that much of the work that a hand might do has devolved upon the skull—not forgetting the toes. So it is that the woodpecker uses its skull as a tool. There are three or four different things it does. It makes the bark fly when it is



GREEN WOODPECKER (*Picus viridis*).

In searching for insects the bird jerks itself rapidly up the stem but pauses at intervals to look round in a very alert way, well shown in the photograph.

trying to get at insects and their larvæ; in some species it bores holes in order to get at the sugary sap, of which it is inclined to take too much; it fixes an acorn in a cleft and breaks it open; it hollows out a nest in the tree, this being especially the male's task; and, finally, it drums on the dry branch with great rapidity, getting rid of some of its excitement in this way, and perhaps sending tidings to its friends.

It is plain, then, that a good deal of work has fallen on the skull.

The most striking adaptation, perhaps, is in connection with the tongue. It is not merely long, cylindrical, barbed at its tip, and covered with a sticky salivary secretion that catches insects very effectively; there is an extraordinary



GREEN WOODPECKER (*Picus viridis*)

One would think that the eggs were very safe in the hole, but the bird seems nervous. Starlings are sometimes bold intruders.

muscular arrangement for working it out and in like a flash. In the Green Woodpecker the arrangement is seen at its best; the muscles of the tongue are fastened to two long curved bones (the horns of the hyoid), which pass backwards and upwards on each side of the windpipe, and continue upwards and forwards in two grooves along the top of the skull till their ends enter the right nasal chamber! Speaking

of the North American Flicker, which well deserves its name, Mr. C. W. Beebe says: "So when this bird stretches out its tongue, the tips of the rear branches leave the opening of the nose and shoot around over the surface of the skull until they have gone as far as possible," which may be two or three inches behind the tip of the beak. As the flicking



NEST OF GREEN WOODPECKER IN STORM-SHATTERED TREE.

Five to seven glossy white eggs form the clutch. White is a common colour for the eggs of birds that lay in dark places.

in is even more rapid than the flicking out, it is evident that the ants have not much chance when the Flicker visits their hill. And we get a biological glimpse of Nature's way of making new things out of very old things when we remember that these extraordinarily elongated hyoid horns of the "laughing yaffle" correspond to the third pair of gill-arches in a fish! They are transformations of these

ancient structures, turned to a use as different as different could be.

There are some kinds of woodpeckers which feed on sap more than on insects, and it is interesting to notice that they have rather short tongues with a brush-like instead of a barbed end.

A very interesting feeding habit in the California Woodpecker has been carefully studied by Professor W. E. Ritter and others. When the acorns are ripe on the trees the woodpeckers collect them and push them into holes in the branches. There they can be more readily broken open or they can be left as a store for days of scarcity. Sometimes there are many hundreds of acorns on one tree, tightly fitted in suitable holes or in holes that have been drilled to suit them. It is not difficult to understand that the habit woodpeckers have of pressing a hard fruit into a crevice and then breaking it might be improved upon by making suitable holes and by gathering a large store. Not very surprising—for there are many similar instances among storing animals—is the fact that hundreds of acorns plugged into holes are left unused. Some of them decay, some of them are treasure-trove to squirrels and climbing rats.

Storing is very rare among birds, but there seems no doubt that it is well on the way among these woodpeckers, and it may be that some of the peculiarities in the harvesting of acorns are due to the fact that the instinctive prompting is still at a tentative stage. We are apt to go wrong by thinking too much of evolution in the past, for it is going on here and now, and woodpeckers are particularly interesting because they illustrate so well the evolving organism's way of sending tremulous tendrils into the possible, feeling for something to which to fasten. There are insectivorous woodpeckers, frugivorous woodpeckers, bibulous sap-sucking woodpeckers, and more besides; they are testing all things, and many of them have determined to hold fast that which is good. But there are others—organically restless, variable, experimental, such as these California Woodpeckers; and when a structural variation, like a lucky card in a "hand," is played effectively by a hustling creature in

the "struggle for existence," then there is evolutionary advance.

From this point of view it is easier to understand the extraordinary mistakes which the storing woodpeckers sometimes make. They are not attending their minds thereunto in an intelligent way, they are obeying instinctive promptings; and at present it does not seem to be of vital consequence whether they store successfully or not. What mistakes do they make? They sometimes store other hard things besides acorns, and when these are nuts or almonds the birds cannot be said to give themselves away. But what are we to make of the not very rare cases of storing pebbles instead of acorns? The incipient instinctive prompting has still a somewhat blunt point. The woodpecker sometimes drops its acorns into places from which they cannot be retrieved. Mr. Morton Pack writes of a species in British Honduras: "I have seen a hollow pine tree with a cavity six or eight inches in diameter filled for a distance of nearly twenty feet with acorns dropped into a good-sized hole at that distance above the ground." Such acorn-filled trees are not uncommon, and their contents may represent the accumulated savings of years. The woodpecker's storing instinct has still a good long way to evolve!

Returning to Britain, we cannot but admire our woodpeckers' nesting. Having discovered by tapping that a tree is decayed at the core, the bird, usually the male, proceeds to make a horizontal porch. He works very quickly, and the chips accumulate on the ground. When a few inches have been excavated, a vertical shaft is sunk in the heart of the tree, perhaps a foot deep. On the floor of this chamber, on a layer of chips, the five or so eggs are laid, very beautiful in their glossy whiteness—white eggs being common in dark nests. The young ones, hatched about May, are naked and helpless at first, and they skip the downy stage. They look rather like young hedgehogs when the feathers are sprouting. Strength comes quickly, and they clamber inside their hole to meet the parent bringing a mouthful of food. Perhaps the decaying wood makes the nest more wholesome than it would otherwise be, but it becomes very



Photo: Riley Fortune, F.Z.S.

TWO KITTIWAKES IN FLIGHT, SHOWING TWO POSITIONS OF THE WINGS.

The kittiwake (*Rissa tridactyla*) is a small northern gull, resident in the British Isles, nesting in large numbers on the insecure ledges of precipitous cliffs. It is a bird of powerful but easy flight, and spends much of the winter in the open sea. It is said to be able to accompany liners across the Atlantic, but it must be difficult to prove this for individual birds.

stuffy and worse; and skilled observers have had the good fortune to see the young woodpeckers taking an airing on the branch before they are ready to fly.

FLIGHT OF BIRDS

If we watch a bird in ordinary flight, we see that the wings begin vertically above the bird's back, and, in the case of the pigeon, we can hear them strike together with a loud clap. Then the wings move *forwards*, *downwards*, slightly



Photo: Riley Fortune, F.Z.S.

KITTIWAKE ON WING.

This photograph must be taken along with that opposite. The three birds together illustrate very clearly the positions of a bird's wings in flight. First of all the wings are almost vertically above the back, as in the uppermost figure. They are drawn forwards and downwards, then backwards, and finally up again.

backwards, and then *upwards*, till they clap against one another again or come near doing so. For centuries it has been usual to compare the flight of a bird to the rowing of a boat, and in a general way it is true that the bird rows in the air with its wings as oars. But there are two big differences to be noticed. The boat floats, whereas the bird has to keep itself up by constant effort. Moreover, in the stroke of the oar there is a large backward component, whereas in birds the backward part of the stroke is much less marked. In the case of the rowing boat the oars displace a large mass of water *backwards*, but in the flight of birds the wings displace a mass of air *downwards* as well as backwards.

Perhaps the ordinary flight of a bird might be usefully compared to swimming with the arms and hands only. The downward part of the stroke keeps the swimmer from sinking, the backward part drives him through the water. But, as we have said, the backward stroke of the wing is less than one would expect. The hard work in flying is bringing the outspread wing downwards against the air, for the bird drives away from itself a large quantity of air, and it is the resistance offered by the air that enables the bird to keep afloat and to leap forwards. The larger the wing the fewer strokes will be needed per minute; the smaller the wing the more rapidly must the strokes follow one another. A stork has 120 strokes in a minute, a crow 180–240, a wild duck 540, and a sparrow 780. But when the bird has got up a certain speed in the air the energy required is much reduced.

A beautiful kind of flight that is often to be seen is gliding. A bird with a large sail-area, like a gull, gets up a certain speed and then rests on its oars. It *glides* along with outstretched wings, like volplanes, but without any strokes. When a gull, flying seawards over the cliffs, meets a breeze in the opposite direction, but rising upwards off the face of the cliff, it often stops flying and begins to glide, *rising* like a kite. In ordinary cases without wind the gliding soon comes to an end, for the bird loses velocity and loses height. We see gliding when a pigeon launches itself from the dovecot and comes gracefully to the ground, putting a brake on at the last moment. Still finer is the sight of a hawk swooping from mid-air on its victim, and, then, having missed it, gliding up again without a pause and without an effort. Sometimes, at any rate, there does not seem to be a single wing-stroke until the hawk has risen many feet off the ground.

THE ALBATROSS

The albatross is an impressive giant among flying birds. It may be bigger than a goose, and sometimes attains to eleven feet four inches from tip to tip of outstretched

wings. Except when it eats so much that it cannot rise, it is eminently "capable" in its mastery of wind and wave. It keeps up with the ship without effort, and sails round and round the vessel with sublime nonchalance. For half the year it is distinctively an open-sea bird ; for the rest of the time the adults are preoccupied with long brooding and parental cares.

The Blackbrowed Albatross has been seen as far north as Britain and California, and there are other species that occur in Northern seas. But the genus is distinctively Southern. The Wandering Albatross or Great Albatross—the kind that the Ancient Mariner slew with his crossbow and afterwards carried round his neck—is most at home in the Far South. Like most of the Southern sea-birds, it belongs to the petrel order. Its proper name, *Diomedea exulans*, recalls an old story of exiles who were turned into birds—probably shearwaters, however. The Spanish-Arabic word albatross is said to mean water-bucket, and the sailors' name, "Mollymauk," which is also applied to the fulmar, seems to mean "silly gull."

As every one knows, the albatross is famous for its "sailing" or "soaring"—the most wonderful of all modes of locomotion. As Mr. Froude said, it "wheels in circles round and round, and for ever round the ship—now far behind, now sweeping past in a long rapid curve, like a perfect skater on an untouched field of ice. There is no effort ; watch it as closely as you will, you rarely or never see a stroke of the mighty pinion." This "sailing" flight, in which the bird describes magnificent ellipses round the ship, apparently without a stroke of its wings for half an hour at a time, requires some breeze, and many authorities believe that the albatross takes advantage of the unequal velocity of air-currents at different heights. In going down the wind the bird sinks a little, but acquires increased velocity ; then by wheeling and tilting its body it turns against the wind and rises again with reduced velocity, changing energy of locomotion into energy of position. This should be compared with the achievements of the modern "gliders."

In "sailing" there are no visible strokes in the ordinary

sense, but it is possible that the bird gives very minute marginal beats, such as an oarsman, having attained a great speed, might give with the tips of his oars.

This heretical view is supported by some observations in Professor H. M. Moseley's *Naturalist on the 'Challenger'*: "I believe that the albatrosses move their wings much oftener than is suspected. They often have the appearance of soaring for long periods after a ship without flapping their wings at all, but if they be very closely watched, very short but extremely quick motions of the wings may be detected. The movements cannot be seen at all unless the bird is exactly on a level with the eye. A very quick stroke, carried even through a very short arc, can, of course, supply a large store of fresh momentum."

Albatrosses depend largely on fishes that swim near the surface, and thus they suffer in stormy weather. For they are not strictly diving birds. They splash into the water somewhat clumsily, and they have often to run along the surface for many yards before they can launch themselves once more into the air. They float buoyantly on the surface of the sea, and their large webbed feet are powerful in swimming. As its food-supply is sometimes precarious, the albatross often dines well, following Dougal Dalgetty's plan of provisioning for three days when the opportunity offers. The drawback is that they are sometimes quite unable to rise off the water.

Those who know albatrosses best say least about their beauty. Admirably fitted as they are for their task in life, their proportions are a little difficult for our eyes. The wings look far too long for the body. It must be noted, however, that five out of the six birds seen following the ship are young ones in immature brown plumage, often "dirty and draggled."

The albatross nests gregariously on islands, sometimes low, sometimes high. At Tristan da Cunha it has found a refuge within an old crater 8000 feet above the sea. Another favourite place is on the top of Inaccessible Island. Sometimes, unluckily for the bird, the nesting-places are readily exploited. At Laysan, for instance, in the mid-Pacific, the

White Albatross nests in such prodigious numbers that it pays to have trolley-cars for the collecting of the eggs. They are sent in shiploads to albumen factories and sugar refineries. The egg of the Great Albatross weighs about three-quarters of a pound, and makes a good breakfast plain boiled.

The nest is somewhat unusual, rising about a foot off the ground, like a big mole-hill with a depression on the top. It is made of packed earth, held together with grass and moss, and it is about a foot-and-a-half across the saucer-like hollow in which the single egg is laid. In the case of the Yellow-billed Albatross, oftenest called the Mollymauk, the nest rises much more abruptly, and has its upper margin overhanging. It suggests a tall hat turned upside down, but the concavity is merely a shallow saucer. The height of the nest in both cases is probably in adaptation to the bird's very long wings, but in some situations it will have the advantage of raising the egg and the nestling off the damp ground.

The mother albatross sits very close, often with the male bird beside her. They snap their bills savagely when approached, making a loudish noise. When the brooding bird is forced to stand up, the large egg, nearly five inches long, slips out of a fold of skin in which it is held between the legs during the incubation. This is an interesting feature which finds its parallel among penguins. The brooding lasts for a long time, probably about two months, but the data are not very satisfactory. To some islands the wanderers come in October, leaving again at the end of March. It is probable that the young birds soon follow their parents out to sea, but there are records of their lingering for several months. If this is correct it means an unusual prolongation of the juvenile period, possibly in adaptation to the subsequent thoroughness of the pelagic life. It suggests that the albatross is long of reaching maturity.

During the breeding season the parents seem to reduce flying to a minimum. They waddle heavily over the ground, and are easily killed by ruthless intruders. Sailors used to make pipe stems of the wing bones, and tobacco pouches out of the webbed feet. The young albatrosses are dark grey in colour, and thus very different from their parents, who

show white above, mottled with wavy bars, and brownish-black on the wings.

The albatross looks so eminently respectable (did not Coleridge call it " pious " ?) that one is rather surprised to hear of courtship antics. Moseley describes the male's appeal as he stands beside the female perched on her mud nest. He raises his wings, spreads out his tail, throws up his head to heaven or stretches it straight out horizontally, and utters a curious cry, swaying his neck up and down. The female responds with a similar note, and they bring the tips of their bills lovingly together. This sort of thing goes on for half an hour or so at a time. No doubt, the birds consider that they are singing. One touch of nature makes the whole world kin.

So, looking backwards, we see that there are three chief kinds of flight among birds: (1) ordinary flight, which is rowing in the air ; (2) gliding, which is like volplaning ; and (3) sailing, which is certainly difficult to understand. In the " soaring " of the lark, the wings are moving up and down with great rapidity, without there being any backward stroke. It may be compared to " treading the water," without moving from the spot.

THE MIGRATION OF BIRDS

Migration is illustrated by many animals, but birds show it best. It is a swing from a breeding- and nesting-place to a feeding- and resting-place. It is like a tide setting in from the south in spring, ebbing from the north in autumn.

Every one who lives in a north temperate country like Britain, notices that there are comparatively few different kinds of birds to be seen in winter. There may be many sparrows, many rooks, many redbreasts, and so on, but the majority of kinds have gone, seeking more genial quarters in the south. But they return in spring, with spring in their voices. In the Northern Hemisphere migration is the rule.

But it occurs in very diverse degrees. A flock of curlews may simply migrate in autumn from the exposed moorland to the low grounds near the shore, whereas the swallows may

fly from Britain to winter quarters far south in Africa. The lapwings or peewits may migrate in autumn from the north of Scotland to the north of Ireland, where the winter is much milder; but the Virginian plover flies from Labrador in the north to Central America. The Pacific Golden Plovers, which spend most of the year in the Hawaiian Islands, which are about two thousand miles away from everywhere, fly north to Alaska to breed, finding their way mysteriously over the pathless sea.

In any north temperate country there are always to be distinguished five sets of birds, considered in reference to migration: (1) There are the *Summer Visitors*, arriving in spring, nesting in their summer quarters, returning to the south in autumn. As examples of this very large company, many of them songsters and most of them insect-eaters, may be mentioned swallow, swift, cuckoo, nightingale, and warblers. (2) Then there is the much smaller company of *Winter Visitors*, that breed in ordinary circumstances in the Far North, and find a country like Britain a pleasant place for the winter. Such are the fieldfare and the red-wing, both first cousins of the thrush, but never nesting in Britain. Such also is the Snow Bunting, on rare occasions nesting on mountains in the north of Scotland. Many northern ducks and divers belong to this group. (3) Relatively few in number are the *Birds of Passage* in the stricter sense, such as the great snipe, the little stint, and some of the sandpipers, which rest on British shores for a short time on their way farther south or farther north. (4) Much more numerous are the *Partial Migrants*. These are birds which never leave the country altogether, but some of them migrate, while others stay on. There is no month of the year when there are not many lapwings and gold-finches to be found in Britain, yet some lapwings and some goldfinches migrate. In some cases the birds of a particular locality move southwards and their place is taken by another set of birds of the same kind, which come from farther north. (5) There remain the strictly *Resident Birds*, which do not migrate at all, such as in Britain the red grouse, the house sparrow, the dipper, and the redbreast.

So that, from the point of view of migration, the birds of a north temperate country may be grouped into summer visitors, winter visitors, birds of passage, partial migrants, and residents.

Brooding birds and young nestlings are apt to suffer from the heat of the sun, and it is thus easy to understand why migratory birds always nest in the coldest part of their range. There are, of course, many birds that are accustomed to live permanently in the tropics, but the migrants that come to the north in spring are seeking a cool place for nesting. Some birds seek out a nesting-place so far to the north that the eggs are seldom seen, and those of the knot are notable rarities.

In the spring there is in the Northern Hemisphere an arrival of immigrants from the south or south-east. The full-grown males often arrive first, and they sometimes, as among the warblers, choose a tree which will be the centre of their summer "territory"—that is to say, if their mate approves of the site. The full-grown females follow on the heels of the males, or may arrive along with them. Last of all come the young birds that will not nest for another year or more.

The autumn tide not infrequently shows a different order, for the younger birds sometimes leave first, starting off on a long journey, which many of them at least have never made before. There is a well-known exception in the case of the cuckoo, for the parents leave their summer quarters a month or more before their offspring are ready. There is nothing to hinder the parent cuckoos from migrating, for they have handed over all their responsibilities to the foster-parents, such as meadow-pipits and hedge-sparrows. As some of the foster-parents are not migratory birds, it looks as if the young cuckoos would sometimes have to make the journey to the south quite unaided. It is very difficult to understand this making for an unknown goal. Another reason why the parent cuckoos should hurry away is that the caterpillars they are so fond of are becoming very scarce.

For some birds it has been noticed that the departure in autumn is very leisurely. They are like people who say

good-bye many times. They flock together, take trial flights, then settle down again. This is different from the arrival in spring, when they seem to be more in a hurry. Audubon notices that the American rice-bird flies by night in spring, and by day in autumn.

The migration has been going on for many thousands of years, and it has become very regular. It is said that some



Photo: Albert Henry Willford.

SWALLOWS RESTING.

This familiar ever-welc[illegible] bird [illegible]ypical summer visitor to Britain. They first arrive in England about the middle of March (May for Scotland), and the height of the autumnal migration is in mid-September. The main trend of the route to winter quarters is from north to south. The swallow has a blue back, chestnut and blue breast-bands; the house-martin is white on the rump and beneath.

Indians name the months from the arrival of certain characteristic birds, and ancient writers have commented on the regularity of the movements of the birds. "The stork in the heavens knoweth her appointed time, and the turtle, and the crane, and the swallow observe the time of their coming." Just as there is considerable regularity in the flowering of certain wild plants in different parts of the country, so is it with the arrival and the departure of the

migrant birds. In both cases the constitution of the creature has been, as it were, wound up to become restless at particular times of the year, but this is linked on to the regular changes of the seasons. The dates may be shifted forwards or backwards according to peculiarities in the weather at a particular place or in a particular year. It is the same with the blossoming of the flowers.

It is not only in their punctuality that migratory birds are remarkable; they sometimes come back to the same breeding-place year after year. This has been known for a long time in connection with storks, but it has been recently proved up to the hilt for a number of other birds. The sure way of proving a fact like this is to mark the bird in some unmistakable way, and then to watch for its return the following year. A good method of marking is to attach to the bird's instep a light aluminium ring, with a break that can be opened and then pressed firm again. On the ring there is printed some name or number. If the proper size of ring is selected, and if it is not put on till the bird is nearly ready to fly away—when the growth in the thickness of the instep is almost finished—no harm will be done to the bird. A swift that was "ringed" in Ayrshire in 1914 was recaptured in the same place in 1918, having doubtless been to Africa four times in the interval. The presence of the ring with the address and the number was certainly proof up to the hilt! Similarly, a swallow marked in Aberdeenshire in 1912 came back with its ring the following year, not only to the same county and parish, but to the very farmsteading which was its birthplace. No doubt many birds go utterly astray during migration, especially when the weather is stormy, but the sample facts we have given show how very exact the journeying may be. There can be little doubt that migrant birds have a very striking "homing" power, of the same rather mysterious nature as the ability of carrier pigeons to return to their owner from great distances.

There are two main ways of finding out where migrant birds go when they fly south or south-east in autumn, or of finding out what route they take, or of answering similar questions. One way is to collect facts from careful observers

on lighthouses, lightships, islands in the sea, passes among the mountains, and so on. For the observers can tell us, for instance, that on a particular date at the end of summer they saw a great crowd of wheatears, let us say, flying due south. A great many observations of this kind have been collected both for the autumn and the spring flights.

The other way is to attach to the instep region of the foot, as we have already mentioned, a light aluminium ring, with an address and a number stamped on it. A small percentage of birds with these rings are afterwards shot or trapped by people who are interested enough to send to the address on the ring a note of the place where they found the bird, and the date. Thus there may be built up a knowledge of the paths that are followed in migration.

Dr. Thienemann, of the Bird Watching Station at Rositten on the Baltic, near the boundary between Germany and Russia, arranged for rings being placed on the feet of a large number of storks in north Germany. Some of these birds were afterwards heard of, and the rings returned with a note of the place and time of capture. When Dr. Thienemann got a ring returned from, let us say, Lake Chad, in the centre of Africa, he put a cross on his big map. When another ring came from the Blue Nile and another from Basutoland, more crosses were registered on the map. In this way there was gradually established a trustworthy record of the path taken by the north European storks in their autumnal flight, *e.g.*, from north Europe to Egypt, and along the line of the Nile Valley southwards. The same has been done with many different birds, and though the inquiry is still young there is a gradually growing knowledge of the winter quarters of North Temperate birds and of the routes the birds take to get there.

Let us notice some of the routes in Europe. Numerous birds congregate in autumn along the southern shores of the Baltic and make their way westwards. Some bands swerve southwards, following the valleys of the Rhine and the Rhone, and thence pass over the Mediterranean to North Africa. Other bands go farther westwards, cross to Heligoland, rest there for a night, continue to the south of England,

and pass thence along the coastlines of France, Spain, and Portugal to the Mediterranean, and thus finish up again in North Africa. In some cases, like the swallows, there is evidence of a more directly southwards flight from north Europe.

Many birds forgather in eastern and central Europe, come down to the Adriatic, follow either coast to the southern end of Italy, and cross the Mediterranean via Sicily to Tunis. Others, collecting in Hungary, Austria, and southern Germany, pass to the south of the Alps across the north of Italy, *e.g.*, along the basin of Po, and eventually reach North Africa by following the coastline of France and Spain, or by crossing the Mediterranean by Corsica and Sardinia, or by the Balearic Islands.

One should not think of the migration-routes in a hard and fast way. They seem to be broad paths, so far as we can judge from our scanty knowledge. Birds of the same kind may winter in different places even when they hail from the same breeding area. The route is often roundabout, and there is great diversity among individuals. Some go much farther than others of the same kith and kin. What we call their "goal" is in part determined by the length of flight that can be readily attained. Some will stop in autumn when they reach the shores of the Mediterranean, while others of the same species will go far into Africa. There is a good deal of flexibility in migration.

It is a striking sight to see from a ship an enormous cloud of birds sweeping along like smoke at no great height above the waves. Larks, starlings, and thrushes are sometimes seen flying low in this fashion. But this is not the way with most birds. Much nearer the average is the beautiful and not uncommon sight of a great V of wild geese making their way northwards in spring in a flight that often keeps pace for a time with a railway train. Thanks especially to the careful observations of airmen, we now know that the great majority of migrants journey at an altitude below 1300 feet, and that flight above 3000 feet is very rare. Geese, cranes, and storks are good examples of high-fliers. Airmen with ornithological experience have recorded a swallow at about

1000 feet and another at 1400, a flock of rooks at 1650, two storks and a buzzard at 2800 feet, a flock of cranes at 4500, a lark at 1000, and another at 6000 feet. The great heights reported for "sailing" vultures stand by themselves and have not to do with migration. It may be noted that ordinary birds seem to be even more sensitive than mammals to the difficulty of breathing at great altitudes.

There has been a good deal of exaggeratiou in regard to the height at which migratory birds travel, and the same is true of the rate of flight. A carrier-pigeon has been known to fly at the rate of 55 miles an hour for four hours on end, and it would be safe to say that many a migrant bird keeps up the rate of half a mile a minute for a considerable time. Careful estimates of the time taken between two points connected by telephone gave 30, 32, 37, and 46 miles an hour for crow, finch, peregrine falcon, and starling respectively. A quickly flying snipe, *with the wind in its favour*, has been known to come near a mile a minute, and many birds can do the same. But the usual pace is probably much less. It must be remembered that when a bird has got up a good pace its flight becomes very much easier, and it is plain that ordinary birds cannot rest when crossing a stretch of sea. On the other hand, it appears that even a strong flier like the stork is not inclined to go on too long. It does a fair day's work when it covers 125 miles in autumn and 250 in spring; and it does not usually care for more than a six-hour day. A coot has been known to cover 160 miles on each of two successive days, and woodcock 250 to 300 miles in one short night. Plover are said to attain to about 550 miles in an eleven-hour day, and there is a well-authenticated story of a marked redbreast which travelled 700 miles in twenty-two days, that is about 32 miles per day.

What a contrast this is to Gätke's stories of hoodie crows crossing 375 miles of North Sea in three hours, or of the little blue-throat journeying from Egypt to Heligoland in a single night of nine hours, which meant a velocity of over 200 miles an hour! Recent observations are wholly against the acceptance of such estimates, but it is probably safe to

say that many migrating birds can keep up a rate of 30 to 40 miles an hour for several hours in succession. When the wind is against the bird, the rate of flight is greatly reduced and the cost to the bird is greatly increased. Every bicyclist knows that against the wind he must go much more slowly, and that he gets much more quickly tired.

This see-saw between two homes—the summer quarters and the winter quarters—how did it begin ? Perhaps part of the answer to this difficult question is to be found in the changes of climate that have occurred from time to time. We know that the north of Europe enjoyed for a long period a more genial climate than it has now. There are, for instance, remains of palm trees and magnolias where these plants can no longer flourish. In those genial days it is likely that the list of resident birds in a country like Britain was much longer than now. It was all the same to the birds whether they stayed in Greenwich or Greenland. But the climate became gradually colder and colder—the Ice Ages set in. Enormous snow-fields covered the north and huge glaciers formed on the mountains. By slow degrees, century after century, most of the birds had to move southwards as the winter drew near. Those that were too dull or sluggish to take the hint would be weeded out, and the same fate would befall those that lost their way hopelessly. The wiser and the cleverer birds would survive and lead the race. In the summer-time there would be a return to the valleys when the snow melted, and the birds probably enjoyed berries and mosquitoes just as those do that go to the north of Scandinavia every summer. But the state of affairs became worse and worse. Almost the whole of Britain, for instance, was covered deep in snow and ice, and all the fine mammals like cave lion, cave bear, mammoth, and woolly rhinoceros, which used to be British, were destroyed or driven south. There were four of these Ice Ages, with three milder periods in between, and we think it may be safely said that some of our present-day migratory birds learned the lesson in those times very long ago. Of course we must not think of birds sitting down and cudgelling their brains over the problem presented by the terrible

ice-sheet drawing nearer and nearer to their pleasant home. They did not emigrate after deliberation like the Pilgrim Fathers. It was probably in a slower, much less conscious way that the custom began and grew. Birds, like most animals, are given to making experiments, and those that made the experiment of taking a long flight southwards



Photo: Albert Henry Willford.

EGGS OF LESSER TERN.

There are usually two or three, stone-coloured with brown and grey markings. They are conspicuous on sand; very inconspicuous among stones.

when the pinch began to be felt in the fall of the year, would be the successful survivors. Gradually the experiment became a custom of the particular kind of bird, and was engrained in its constitution. It may seem a hard saying, but it is almost certainly true, that birds do not take thought for the morrow.

But without going back to the Ice Ages, which began several hundred thousand years ago, we may think simply

of the march of the seasons as we know them to-day. Even an ordinary sort of winter means cold, stormy weather, a short daylight, scarcity of fruits and seeds, insects and slugs. Thus meeting, or evading, or circumventing the winter is for many creatures a pressing problem, and the neatest solution of all is to migrate. That this was part of the reason for the origin of the migrating custom is almost proved by the occurrence of what we have called "partial migrants"—birds that do not absolutely need to flit, but yet prefer to do so.

There is a third suggestion. The migration at the end of summer may have something to do with the fact that each pair of birds has now a family, and sometimes two families. That means that there are a good many mouths to fill, while the supplies are becoming reduced, not increased. There is often a tendency to over-crowding, and migration is a way out. To sum up then, we can think of birds beginning to migrate because of great changes of climate, because of the difficulty of the winter, and because a little one soon becomes a thousand.

Those who study the races of mankind sometimes apply the word "folk-way" to a custom that is handed on from generation to generation without ever becoming a law of the tribe and without being clearly thought out as a wise kind of thing to do. Thus it may be a "folk-way" to drink nothing but milk, or to shift the camp every year about the same time. Perhaps the yearly migrations of birds may be called "bird-ways," but they are continued from generation to generation by heredity rather than by tradition. That is to say, the prompting to migrate and the ability to migrate with considerable success are *inborn* in the bird. Of course birds may use hints that they get from their neighbours, and they may help themselves by using their keen senses and good brains, but in the main their success in "changing their season in the night" is a gift, rather than something gained by experience as successful travellers.

It has been noticed that *caged* birds, made as comfortable as the mistaken kindness of man can devise, sometimes get restless at the migrating time. This means that their whole

being is " wound-up " to a regular routine, and it must be kept in mind that the restlessness is shown by birds living alone, that have never known a winter, that never made any journey whatsoever. But that is not denying that birds are sometimes influenced by the restlessness of their neighbours, for that seems quite evident. We once brought up Black-headed Gulls in the laboratory by means of an incubator in order to see what they could do without any help from parents or friends. We were the foster-parent and the young birds got on very well by themselves. They showed, for instance, that they were born with their minds well made up in regard to what was good for them. For we could not get them even to try little pieces of useless stuff like paper or tobacco. To return to migration, however, our point is that when the migrating time came and the young birds were making little flights, they began to take an interest in their kindred, who flew overhead across the lawn, preparing to leave Aberdeen for milder winter quarters. Our idea is that the sight and hearing of these kinsfolk pulled the trigger of some promptings and memories in the young gulls' brain, for one day they rose from the garden, where they had been very happy, and went off on their great adventure with their kindred.

In one of his poems Matthew Arnold speaks of the restlessness of the tethered stork when he sees his kinsfolk flying overhead in autumn :

" And as a stork which idle boys have trapped,
And tied him in a yard, at autumn sees
Flocks of his kind pass flying o'er his head
To warmer lands and coasts that keep the sun,
He strains to join their flight and from his shed
Follows them with a long complaining cry."

When a young coot tumbles off the nest into the water it begins at once to swim ; the water presses the spring of its inborn capacity for swimming. What may there be in the life of the migratory bird that presses its spring ? We have just spoken of the kindred, but the question is why *they* became restless. Part of the answer is perhaps plain when we think of the state of affairs when the summer is over and

gone. Food is becoming scarcer, especially seeds and fruits, insects and slugs ; the day is becoming shorter, so that there is less time for hunting ; there is beginning to be a nip in the air and the weather is unsettled. The more difficult part of the answer is that there are changes within the bird's body which awaken memories—memories older than the individual bird. There are promptings from within as well as spurs from without. In any case we must turn out of doors any idea of the bird looking forward with dread to the hard times of winter, and saying to itself, " It is time to be off." This cannot be the right view, for it is enough to remember that none of these thorough-going summer visitors have ever had any experience of winter. The poet is quite right : they "know no winter in their year." More than that, none of their ancestors ever knew a winter for many thousands of years.

The outside hints that birds receive in autumn are what one might call broad hints, for the conditions of life are becoming uncomfortable. But it is not so easy to be sure what the outside hints are that lead birds to leave their winter quarters to make a long journey to the north. Probably they include the high summer temperature, the drought, and the glare of the sun.

We cannot shut our eyes to the fact that there is often a thinning of the ranks during the migratory flight. Some birds lose their way in flying across the pathless sea in stormy weather. They become bewildered and exhausted ; they sink into the sea and are drowned. We have watched small birds arriving in Cornwall in the spring after a northward flight, and some of them seemed very weary, recalling Tennyson's lines :

" Faint as a climate-changing bird
That flies all night across the dark,
And on the threshold of the land
Sinks to the earth and can no more."

Others are overtaken by very cold weather and perish; some hundreds have been gathered on the streets of a little town. Others are attracted to the lighthouses and dash

themselves against the windows, while others still fall under the beaks and talons of the hawks and other captors. All this is true, but the larger fact is that so many of the travellers make the journey successfully. They reach their goal and they return next spring to the north. Can any light be thrown on their way-finding?



Photo: Albert Henry Willford

FEMALE COMMON SNIPE BROODING OUT IN THE OPEN.

The common snipe (*Gallinago gallinago*) is a bird of the moors and marshes, keeping under cover till dusk, then making for soft mud, where it probes for worms and the like. Its nest is a well-concealed grass-lined cup. The photograph shows the long sensitive bill.

No doubt some of them take advantage of coast-lines, river-valleys, mountain ranges, and chains of islands. An observer saw a stream of migrant birds passing from the mainland to the nearest island—the first step on their oversea voyage. Yet when a fog came on and hid the island from view, the

birds flew along the coast-line. Many years ago we spent a short autumn holiday on Heligoland, and it was interesting to watch the flying squadrons of birds that settled on the island for a rest, sometimes for the night, and continued their journey after a while. One squadron came after another, as if the waves behind impelled the waves before. But we must not think that the way-finding of birds is altogether explained by the birds' ability to use all sorts of landmarks. That cannot be the whole answer, for many birds fly at night and many cross stretches of ocean where there is nothing to be seen even by day.

Even if we suppose—it would not be more than a supposition—that an individual bird could hand on to its offspring the results of its own experience, there would be the difficulty of understanding what the experience would consist of in the case of birds flying by night, at great heights, and across the trackless sea.

There is the same difficulty in regard to the theory that some migratory birds keep up a kind of tradition of successful travelling. Those who followed well for several years might become good leaders in the course of time. This is an attractive idea, and there may be something in it ; but it cannot be the whole truth, for we have noticed already that the young birds usually start for the south before their parents. There is the further difficulty that it is hard to say on what the tradition would be based. We can understand guides on the Alps handing on to their apprentices and sons the secret of difficult climbs. One would say to the other : " When you come to that corner you must climb the face of the cliff for fifty feet," and so forth. Even if they were dumb, the tradition might be established, for the way out of the difficulty could be shown by father to son, generation after generation. But in the case of birds migrating, as some of them do, at night, at a great height, and across the sea, what would there be upon which to base the tradition ?

So we do not see what can be done at present except to fall back on the interesting old view that birds have in a high degree what many animals have in a small way—*a sense*

of direction. There are men who can walk from the railway station into the heart of a great city they never visited before, and then, after an hour of winding streets and many corners turn on their heel and go back to the station. In some way, which cannot be easily explained, they register in their nervous system the broad features of their walk from the station, and they return without mistake. There is some sort of memory of movements, to which these people trust, which is quite different from the painstaking memory of ordinary people who make mental notes of conspicuous buildings and striking shop-signs and peculiar street names. The power of " finding their way home " is also seen in cats, dogs, horses, and cattle ; but there is, unfortunately, a good deal of hearsay mixed up with most of the stories.

At the mouth of the Gulf of Mexico there is a group of islands called the Tortugas, and one of them, named Bird Key, is the breeding-place of two southern terns—the noddy tern and the sooty tern, which do not go farther north.

Two students of animal behaviour, Professor J. B. Watson and Dr. K. J. Lashley, resolved to experiment with the terns to find out what they could do in the way of " homing." At the nesting time they caught strong, vigorous birds and marked them with labels and a little oil-paint, marking the nest with the same number and date. The tern was then put into a large hooded cage, taken on board ship, and then liberated at some selected spot. The birds were not allowed to see anything, but they were, of course, well looked after. They got plenty of minnows from the refrigerator.

Very remarkable results followed. From Galveston, the capital of Texas, 800 miles from Bird Key, some of the terns returned. The time they took varied greatly ; some took six days, others twelve. Three sooties taken to the island called Key West, only 65 miles off, returned in 3 hours, 45 minutes, but they probably spent part of that time on the feeding-ground before reporting themselves at their nests. From some journeys of over 500 miles some terns returned in 3–5 days, but the time they took must not be regarded as indicating the rate of flight.

Two noddies and two sooties were taken in the stateroom of a steamer to Havana and liberated in the harbour there early in the morning of 11th July. Next day they were back at Bird Key. This was a journey of 108 miles, but a large part of the time was probably spent off the shores of Cuba. Of five birds liberated off Cape Hatteras, which is half-way to New York, at least three returned in a few days, having accomplished a journey of 850 miles "as the crow flies," and much more if they followed the alongshore route. Here it must be remembered that these northern waters were altogether new to the birds, for the Tortugas mark the limit of their ordinary range.

Four noddies and four sooties were taken in a hooded cage on a Galveston steamer to about 461 miles from the nesting island, and liberated where no shore line was visible. The vessel was steaming westwards, of course, but when the eight birds were liberated all but one started east. That one headed west and continued for about 200 yards, then turned suddenly and flew eastwards like the others. They had a strong head wind against them throughout the first day, but two of the noddies returned in safety to Bird Key. Sometimes they were not so successful. On 4th June, eleven birds were set free in Galveston Harbour, 800 miles from home; on 9th June one of the observers, travelling on the steamer to Bird Key, saw one of his terns (a red-marked sooty) resting upon a piece of driftwood in the open sea more than half-way home—about 409 statute miles east of Galveston. Unfortunately the setting in of stormy weather prevented a successful return.

What these experiments clearly prove is that nesting birds, with some inducement to return, can find their way home from a distance of 800 miles or more across seas or along coasts unknown to them, and without having had any vision of where they were travelling on the outgoing voyage. The observations are very satisfactory, but they do not throw any light on the problem of where the sense of direction has its seat.

It is evident that the way-finding power exhibited by migratory birds remains in great part a puzzle. We do not

really understand how they find their way so successfully to an unknown goal—namely, their winter quarters in a southern country which is to the young birds a *terra incognita*



THE MIGRATION OF THE WHITE STORK, AS SHOWN BY RINGING RECORDS.

The principal winter quarters of storks from Europe are in Africa, from the headwaters of the Nile south to the Transvaal, Orange Free State and Cape Colony.

indeed. Nor do we understand their return the following year to their summer quarters, even in some cases to their particular birthplace. In face of such puzzles it is useful to

consider somewhat similar facts, such as the power some human beings and some mammals have of finding their way home, often over difficult country. It is possible that some light on ordinary migration will be found in a careful study of homing pigeons, but their remarkable accomplishments are largely the result of careful selective breeding and of patient individual training. To begin with, they are educated for short distances, in the same direction from home. Those birds that prove themselves " non-educable "—often a large percentage—are soon relieved from further tuition, but the good learners can find their way home from a distance of 200 miles before they are a year old. A full-grown carrier pigeon can often return from 500 miles, and there are some much more striking records. Thus there was one that flew 634 miles in one day of eighteen and a quarter hours, and another (in America) that covered 1010 miles in thirty-five and a half hours, including night stoppage. A noteworthy fact is that the carriers take disproportionately longer when the distance is much increased. Thus a week may be spent over a two days' distance. This suggests that there is considerable searching about for landmarks, and that keen vision and topographical memory contribute greatly to success in homing. This is corroborated by the fact that the pigeons do not fly by night, and that they are in varying degrees bewildered by fog. When they are liberated they usually ascend to a great height and describe a circle, as if they were taking their bearings. It must be noted that there are many failures, as well as geniuses. In a famous Rome to Derby flight of a thousand miles or so we believe that only two carriers, out of 106, succeeded in finding their way home, and one of these took twenty-three days. This strongly suggests that many tentative flights were made in various directions before remembered landmarks were reached.

ARCTIC BIRDS

It is hardly possible to form anything like a true picture of the life of the Arctic Ocean without taking account of the innumerable birds that return year after year to

its cliffs and islets to breed. A few birds are resident all the year round even on the ice-bound shores, and for many months these must pick up a scanty living as best they can. Gulls and fulmars are not very fastidious anywhere!



Photo · *W. S. Berridge, F.Z.S.*

RAZORBILL (*Alca torda*).

A summer visitor to European and North American coasts, where it "nests" on the cliffs, laying a single toy-shaped egg on a narrow ledge. During the rest of the year it is a bird of the open sea, except in stormy weather. The bill is deep and laterally compressed, with transverse grooves; the breast is brilliantly white; the upper parts are black. When the bird is sitting, the whole of the instep (tarso-metatarsus) is on the rock. The bill is flatter than the photograph

The great northward inrush of birds begins in May, when the ice is beginning to melt. The eider-ducks come only after all the ice that joins up the little islets has gone, for

only then are they safe from the depredations of the Arctic Fox. They form close colonies round these islets, and there bring up their large broods, finding abundant and easily obtained food in the layers of water just beneath the surface. For the shore-birds and waders a rich table is spread at every ebb-tide, when the mud-flats with their wealth of soft-bodied animals are uncovered. Above the water-line no food is to be found, for the rocks are polished smooth by the friction of the ice.

But the characteristic feature of the Arctic shores is the abundance of cliff-nesting birds—the swimmers and divers that depend, not on the shore, but on the sea itself. Not every cliff or rocky islet is deemed suitable. It must be inaccessible to beasts of prey, be sheltered from the bitterest winds, and as fully exposed as possible to the rays of the sun. Every cliff or rock that fulfils these requirements is quickly colonised by a dense crowd of birds, chiefly razorbills, guillemots, and little auks, with puffins wherever there are hollows that admit of burrowing. Brooding and fishing go on all day and throughout a great part of the clear night, for birds can do with very little sleep.

With this intensive feeding the young birds grow very rapidly. There are many casualties, and the robber gulls levy a heavy toll, but by mid-August the young birds are ready to fly with their parents to less severe lands, there to spend the winter resting and feeding quietly, and so preparing for the northward flight, and the brief spell of love and labour which is the climax of their year.

Very charactieristic of the Arctic Islands is the Little Auk, a relative of the extinct Great Auk. It is a fascinating bird. At the point of a rocky promontory, jutting into rather deep water, there is, on the southern and sheltered side, a veritable naturalist's chair, where the observer becomes, as it were, part of the rock. There, one winter day, almost genial, we sat for a long time very still, and we had our reward. For to our feet, within touching distance, there came a Little Auk that had paddled round the corner as quietly as a water-shrew in a pond. A most attractive winter visitor it is, neatly dressed in black and white, hardly

more than six inches in length, with webbed feet, a very short tail, and hazel eyes.

A big soul in a little body, this "Ice-Bird," which habitually braves Arctic conditions. It feeds daintily on minute



Photo: F. W. Bond.

GUILLEMOT (*Uria troille*) IN WINTER PLUMAGE.

The Common Guillemot is a bird of the North Atlantic and North Pacific, like the Razorbill in its habits. It is a browner, less compact bird, with a longer neck, and a long sharp-pointed bill. It swims and dives well, using its wings under water; it flies swiftly, skimming near the surface; like other auks, it is for the most part a fish-eater.

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In very stormy weather we have found dead Little Auks twenty miles from the coast; it looks as if they sometimes got flurried and flew headlong anywhere.

THE NORTHERN DIVER AND OTHERS

It is a rather cold pleasure watching birds at the mouth of the river in December, but we are always warmed when the Great Northern Diver appears on the stage, and that is to be expected in mid-winter. For many weeks he is in evidence, though not necessarily every day, for he is oftenest seen when it is rough weather out to sea. He cannot be always baulking the billows, so he comes in for a rest. And there is good fishing in the quiet estuary, whereas a prolonged storm in the open sea sends the upper zone fishes into the deeper waters, out of even the Diver's reach. This, indeed, is the greatest risk that open-sea birds have to face, that their normal food may sink into inaccessible depths. After a few days of short commons the bird loses tone and becomes unable to stand up to the sea of troubles.

The Great Northern Diver is an almost invincible bird and at home in stormy northern waters, but even he, to our delight, is appreciative of a rest in the waters of the estuary. Many go far inland to quiet lochs, where they must enjoy a real winter holiday. A much more familiar Diver at our river-mouth is the Red-Throated Diver—a smaller, perhaps more graceful, bird—hardly so impressive as its big cousin.

We respect the Great Northern Diver as a bird of long pedigree, a veritable antique. It takes us back to the great extinct Hesperornis, a wingless, toothed, small-brained diving bird, about five feet in length, that hunted for fishes in the Cretaceous seas many millions of years ago. It had extraordinarily powerful hind-legs, probably of no use on land, but admirably suited for swift swimming and deep diving. The Great Northern Diver or Loon is a scion of the house of Hesperornis. It is a living reminiscence.

Not less convincingly, the efficiency of the Great Northern Diver wins our respect. Its swimming and diving are unsurpassable, and though it cannot rise from dry land, and requires the momentum of its swimming, and perhaps of a

wave, and very rapid wing-beats when it launches itself off the water, it is quite capable of a long flight, at a considerable altitude, and at a great pace. In the air it presents an unusual appearance, with its long thick neck stretched out in front, and its wings set far back and working very hard. It suggests one of the extinct flying dragons or Pterodactyls: in any case, it does not look modern.

The diving is such a rapid somersault that very few people can see what happens. The bird disappears head foremost, after a quick turn in the air. The powerful feet are the chief instruments in swimming and diving, but the wings may also be used a little under water. There is a remarkable upward process of bone at the knee-joint, to which muscles are attached with great effect. An additional leverage is secured that adds greatly to the strength of the stroke in swimming and diving. It is an interesting point that the same kind of knee-process is seen in grebes and in Hesperornis, with the same meaning in each case, and yet the details of the making of the instrument are on three different plans.

The strength of the Great Northern Diver may be inferred from Saxby's story of one which pulled a light thirteen-foot boat, made of Norway pine, for several minutes by means of a rope attached to one foot. And it was slightly wounded, too! But its feats on the open sea in stormy weather are in reality much more interesting. Somewhat puzzling is its way of slowly sinking in the water, just the opposite of the quick dive. It goes straight down like a sinking ship, till only the head is visible. We hope some one knows how the trick is done. It is sometimes followed by a genuine dive without the usual somersault. The duration of submergence is in most cases about two or three minutes, but it is a little difficult to be quite sure that the bird does not pop its head up for a few seconds.

The Great Northern Diver or Loon is one of the handsomest of sea birds. The upper surface is black, ornamented by belts of quadrangular white spots, which produce what is called the chess-board pattern; the under parts are white; the throat is black in summer, but crossed in front by two bands of white, streaked with black. In the

winter the fore-throat is white. Of course, there is much more colour than this, for the black has an indescribable metallic sheen at the breeding season, and there are little details like the blue-black bill, the greenish legs and the crimson iris. There is no difference between the sexes; they are equally handsome.

The Great Northern Diver is a typical winter visitor to Britain, or it may be a bird of passage when it seeks its winter quarters as far south as the Mediterranean. In spring they make for the North again, for they never breed in Britain, nor at any station nearer than Iceland. Their true home is in the Far North—in Greenland, in the fur countries, and on the northern coast of Asia. There is something of the melancholy of the North in their wails and growls; their more musical and victorious love-call we have not been fortunate enough to hear. The nest in the Far North is usually by a fresh-water loch and very near the water, for the birds are very awkward on land. There are two brownish eggs, which are incubated for about a month by both parents. The young ones are said to take to the water in a few hours, and their immediate skill in swimming, diving, and fish-catching illustrates what is meant by instinctive behaviour. They move on land by frog-like leaps, and much less awkwardly than their parents. This is readily intelligible, for young creatures are often nearer the ancestral type.

A bird always nests in the coldest part of its migratory range; the Great Northern Diver in Iceland and Greenland; the Little Auk in Spitzbergen and Novaya Zemlya; and the Snow Bunting in the same regions, as well as in the Faeroes, North Scandinavia and North Russia. Occasionally, indeed, the Snow Bunting nests in the screes of the Cairngorms and the like; but this is the sort of exception that proves the rule. Thus, just as our summer visitors fly south in the autumn, so the three birds we have mentioned (and others, like some of the Diving Ducks) are the summer visitors of the Far North *who find our shores passable winter quarters.*

THE GOLDEN-EYE

One of the many compensations for wrestling with the severities of winter in North Britain is the opportunity of studying Golden-Eyes. To many estuaries they come every year about the end of November and stay with us till March. If there are halcyon days, these diving-ducks disappear and explore the shallow waters up and down the coast; but when there is stormy weather they come again to the shelter of the river mouth. They always swim about in a flock, sometimes as many as thirty together, full-grown males and rather smaller females, and some youngsters in their first year. Though they are not dumb, we have never heard them say anything, and yet they give us the impression of being a very joyous company. What strikes us at once is the dazzling white of part of the plumage against the adjacent black or brown; and even from a distance one can see a large white spot at the base of the bill of the full-grown drake. The contrast of black and white accounts for the name "magpie-diver," which is often applied to this species, and the gilded iris of the drake accounts for the beautiful name Golden-Eye.

This bird is a thoroughly good example of a winter visitor, for there is no secure evidence that it ever breeds in Britain. It nests in the north of Scandinavia and Russia, and eastwards into Asia, but it leaves these northern latitudes in the autumn and betakes itself to southern estuaries and coastal waters and fresh-water lochs. In March or April it becomes restless and leaves us for farther north. It is thus for Britain a typical winter visitor.

The Golden-Eye belongs to the group of Diving Ducks, which includes, for instance, Pochard, Tufted Duck, and Scaup, the point being that, instead of paddling in the shallows, like mallard, teal, widgeon, and domestic duck, they prefer to dive in deepish water. Indeed, the Golden-Eye is at times almost incessantly diving, being in the course of half an hour oftener below than above water. Mr. Coward found an average of twenty-three seconds below the water, and three or four seconds on the surface between each dive.

It has been estimated that four-fifths of the day may be spent below the surface, but a flock may often be seen swimming hither and thither without diving at all. We suppose this means that they have eaten enough for the time being, and have nothing to do but to amuse themselves.

Could the Golden-Eye's diving be improved on? The plunge is extremely rapid and forceful, and the reappearance of the bird is sometimes just where it dived, sometimes at a distance.

As we watch from the bank we cannot but admire their defiance of cold and their apparently inexhaustible energy, as they emerge and disappear again, time after time, hour after hour. We know, indeed, of their perfect warm-bloodedness, that the temperature of their body never changes; we take account of the unwetted plumage, the thick quilt of non-conducting down, and the fat below the skin; we are willing to allow that, since they come from the Far North they possibly find our winters genial; but, when all is said, the diving of the Golden-Eyes is a fine achievement. Our feet get cold as we stand watching them; why are their yellow feet not cold, having neither boots nor stockings? No doubt the Golden-Eyes have a first-class circulation, and although they come ashore occasionally, they are usually moving about restlessly on the water.

In our estuary the bird feeds mainly on small crustaceans and molluscs which it finds in the mud; in the shallow water along the shore it searches for mussels and shrimps; in the inland lochs it depends to a large extent on fresh-water snails and the larvæ of insects. No doubt it sometimes eats fresh-water plants, sea-grass, and seaweed, but on the whole it feeds on small fry, which it transmutes into its tireless energy and wonderful beauty. We do not suppose it has many enemies.

As the Golden-Eye is a winter visitor, we owe our knowledge of its family affairs to those observers who have been able to follow it farther north. The drake shows off a bit, swimming round the female. He raises his bill to the zenith and utters a loud, rasping disyllabic cry. He jerks his head back again, and strikes the water violently, showing his

orange feet all aflame. In North Britain, as we have confessed, we have never ourselves heard the Golden-Eye utter a cheep, but expostulatory grunting is well known.

CONCERNING PUFFINS

The common puffin is a member of the very well-defined family of auks, which includes Little Auks, guillemots, razorbills, and, of course, the extinct Great Auk. They certainly have a strong family resemblance in shape and carriage, which points to their being adapted to an open-sea life, for swimming and diving even more than for flight. Not that they do not fly well enough, but the wings are short and narrow, and there is something ominous in the doom of the Great Auk, which was in part due to its having lost the power of flying. Most of the auks are black and white; most of them breed gregariously on precipitous cliffs and rocky islands, dispensing with a nest; most of them depend in the main on fishes; all of them are birds of the north. They form a family worth knowing.

There is a peculiar charm about the puffin, though he is not so much of a "character" as he looks. In an account of diving birds (U.S. National Museum, Bulletin 107, 1919), Dr. C. W. Townsend gives us the initial picture we need: "The puffin is a curious mixture of the solemn and the comical. Its short, stocky form and abbreviated neck, ornamented with a black collar, its serious face and extraordinarily large and brilliantly coloured bill, suggestive of the false nose of a masquerader, its vivid orange-red feet and legs all combine to produce such a grotesque effect that one is brought almost to laughter on seeing these birds walking about near at hand." To watch a thousand of them at midsummer on such breeding-places as the Bullers of Buchan is to enjoy one of the most cheerful spectacles in the world.

They are fortunate in most of their many names, for puffin sounds all right ("*a naturali voce*," an old writer says), and the appropriateness of "sea-parrot" and "coulter-neb" (like the fore-iron of a plough) is clear. There is a

suggestion of mingled affection and amusement in "Tammy-Norie," but most of all we like the Linnæan technical title *Fratercula arctica*, our "little brother from the north." As every one knows, the puffin is a summer visitor to our coasts, arriving in April or May in huge numbers, and with great local punctuality, staying for the breeding season, and disappearing again about the end of August for its real home in the more or less open sea. In one locality in the Hebrides, Professor Newton estimated the puffin population during the breeding time at about three millions, but the confiding and simple nature of the bird has played into the hands of ruthlessness, and the result has been a terrible thinning of its cheerful ranks in most parts of the world. There was some excuse in old times, when the plump birds were eaten; there is very little excuse now.

As they stand at "attention" on the cliffs, puffins look as if they were on their tails, but that is, of course, an illusion. They stand on their feet like other birds, and when they walk about in their quaintly dignified way it is only at times that more than the toes are on the ground. From the bolt-upright position the body often sinks down to the horizontal, like that of a duck, and when they are about to spring from the cliff, the instep, as well as the toes, may be pressed against the rock. The flight is rapid, and the quick beating of the little wings makes a whir; great curves are often described, and baffling zigzags; the orange-red webs of the toes are spread out to each side when the birds alight with a splash in the water.

It is delightful to watch score after score launch themselves, wings up and heads down, from a high cliff, whir close past one, and, after a fine sweep, reach the crowd already bobbing in the sea. "On the surface they paddle along skilfully, like little apoplectic short-necked ducks, and their small orange-red legs are plainly visible. Their diminutive tails are sometimes cocked up at an angle." But perhaps the most interesting fact in regard to the puffins' movements is that they fly under water, the feet trailing behind, just as in aerial locomotion. This is true of other members of the auk family, but some use feet as

well as wings in diving. It is rather striking that the puffins' movements of propulsion should be much the same in swimming under water and in flying, but one remembers that land-mammals, when tumbled into the sea, usually swim by continuing their walking movements, a method which, unfortunately, does not work in our own case. Another point is that the puffins in flying under water are



Photo: C. J. King & Son, Scilly.

BRINGING FOOD TO ITS YOUNG ONES.

The puffin may have four or five fish neatly arranged crosswise in its beak. How does it add to the number without losing all?

doing what the penguins of the south, with which they have no relationship, practise so skilfully; and that the water-ouzel or dipper, has begun the same sort of habit. This was not the way with the extinct Hesperornis, a toothed aquatic bird about five feet long, which swam by strokes of its powerful legs, and had wings dwindled almost to a vanishing-point. Unless helped by a strong head wind, puffins seem to have considerable difficulty in rising from the water, and they often splash along the surface for some

distance before they get launched into the air. But when they are fully a-going they fly well.

Dr. Townsend notices a very interesting point: "Flocks wheel and turn together with the regularity of shore birds, now showing their black backs, now flashing out their white breasts and bellies." This is a striking Natural History corroboration of what the anatomists tell us, that the auks are related to the plovers. But the resemblance in mass-flights between the two groups is almost the only point in which their habits agree. How different, for instance, are the voices, for the puffin, though not very talkative, purrs and croaks, laughs in its throat and groans. We concealed ourselves once where puffins nested, and we rarely heard such sounds. In fact, we have always been afraid to speak of them, and would not have dared now had we not come across the description given by Mr. Edmund Selous: "The note of the puffin is very peculiar—sepulchrally deep, and full of the deepest feeling. Another note is much more commonly heard, namely, a long, deep, slowly rising *awe* uttered in something of a tone of solemn expostulation, as though the bird were in the pulpit."

When puffins come to our shores at the beginning of summer, they come to mate and breed, but first there is the courtship. Dr. Townsend writes: "They swim together in closely crowded ranks, rarely diving, for their thoughts are not on food. At frequent intervals individuals rise from the water and flap their wings as if from nervousness. Again two males fight vigorously, flapping their wings meanwhile and making the water foam about them. Again two, possibly a pair, hold each other by the bills and move their heads and necks like billing doves.' Now several are seen to throw their bills back with a jerk until the bill points up, and this is repeated several times." Mr. Selous notes that although the bill is opened wide, no sound is uttered. The inside of the mouth is brilliant yellow, and the display of this probably forms part of the courting ritual. It is at this season that the bill is at its best, and it is extraordinary in its coloration. There is a mingling of bright scarlet, steel blue, orange, and white, while the edge of the eyelids

is a vivid vermilion. The sparkling eyes themselves are blue-black. If the brilliance of the bill is connected with courtship, as some ornithologists suggest, it is remarkable in being the same in both sexes!

But the most interesting thing about this wonderful bill is that the brightly coloured sheaths are moulted every year. This is seen in other kinds of puffin, and in some measure in some more distantly related birds, such as the razor-bill.



Photo: W. S. *Berridge, F.Z.S.*

A NESTLING PUFFIN

It has long, sooty down, with a whitish patch below. Later on it becomes greyer, and the slate-grey legs become pinkish. It is an active nestling and it pipes when the parent arrives with a mouthful of fish

When the shields fall off, there is a change in the shape of the bill and a reduction of the size to about a half. There is also a moulting of the little horny outgrowths above and beneath the eyes. Before the next breeding season all is restored. Whether the curiously grooved and embossed shields, which are of use in fish-catching and fish-carrying, get worn and loose, *e.g.*, in fighting, and require renewal more than in other birds, we do not know; but the peculiarity, like the shedding of the claws in grouse, takes our thoughts back to the moulting of the scales in reptiles.

The horny encasement of the bird's beak, often consisting of a good many pieces (about nine in the puffin) is undoubtedly a legacy from reptilian ancestry, and the puffin's annual bill-moulting is a disclosure of pedigree.

Another peculiarity concerns the egg-laying, for while almost all auks lay on a bare shelf, the puffin is a burrower or utilises a hole made by a rabbit. The burrow is often just about the length of one's arm—a statement not to be verified without gloves if the puffin is at home. When it has to be made, it is chiefly the task of the male, who uses his toe-nails with zest. A burrow may have two doors, and several burrows sometimes communicate. At the extreme end is a rough nest of dry grass, sometimes with a few feathers, and in this there is usually a single egg, dull white in colour, occasionally blotched. The contrast between the whiteness of the hidden egg of the puffin and the many colours of the exposed egg of the guillemot or the razor-bill is very striking. We wonder whether we should say that hidden eggs are usually white or that white eggs are usually hidden—a question dividing Lamarckians and Darwinians still. Both parents brood, but the mother seems to be the more assiduous. Hatching occurs in about a month, and after that the young one has to be fed for four or five weeks. The parents bring in fishes, two or three inches long, several—up to eight—at a time ; and these are held crosswise in the mouth. It is difficult to understand how the number is added to without losing previous captures; but it may be that the tongue and some spines in the mouth keep hold when the jaws are opened. The young bird's first coat consists of long, soft, thick down, brownish-black above and whitish below ; this gradually gives place to the characteristic black and white plumage. When summer is over there is not a puffin to be seen on the cliffs where there were thousands—the young have followed their parents to the open sea.

Mr. A. C. Bent has given us, in a monograph, a very interesting account of other puffins. There is the so-called horned puffin of Alaska and the Behring Sea, which shows above its eye a soft raisable excrescence, repre-

sented by a small process in our "Coulter-Neb." In certain localities the horned puffin's tunnel has always two openings, which are used indiscriminately, and the "nest" may be at almost any distance from two to ten feet from the face of the bluff. The young bird is taken by the parent from the nest before it is quite



Photo: C. J. King & Son, Scilly.

THE PUFFIN'S BURROW.

This may be a rabbit's, but it is usually excavated by the bird itself. The bill is the pickaxe and the feet scratch the débris outwards. There is no uniformity as to length of burrow; it varies from several inches to a few feet. Sometimes there is a back door, and it is much needed.

able to fly. The bill is partly used in climbing, and this seems to wear and loosen some of the plates. Nearly related is the tufted puffin of the North Pacific, which breeds on the Aleutian Islands, where it is very welcome to the Aleuts as a change of food after a winter of salted seal. The skins are made into a warm and light hooded garment, worn with the feathers to the inside. The faces are white, and there are flowing white plumes on the head which

suggest snowy locks, and explain the popular name, "old man of the sea." The tufted puffin uses feet as well as wings under water, but it is not fond of diving. It is an extraordinarily hardy bird, very tenacious of life, voracious and aggressive; it holds on like a bull-dog with its jaws, and can bite to the bone with its bill. It is hardly true to its name Fratercula, which means little brother.

ANTARCTIC BIRDS

When we turn from the Arctic regions to the Antarctic we find very different conditions. Instead of a Polar basin surrounded by land there is a great continent at the South Pole. This vast land mass is perpetually covered with ice and snow. No higher plants grow there, but only a few mosses and lichens, among which lurk sparse and stunted representatives of insects and other invertebrates. When there are few insects there are necessarily few land birds; when there are no grasses or flowering plants there cannot be herbivores, and without these there can be no carnivores. Thus "in an area of five and a half million square miles, or a continent the size of Europe and Australia together, there is not a single mammal."

The reason for the contrast between the animal and plant life of the north and the south lies in the climate. The mean temperature for the year is much the same for similar latitudes, but the distribution is more uniform in the south. The winters are not quite so cold, and the summers are not quite so warm, the temperature rarely reaching what is necessary for plant growth. Add to this that bitter winds blow frequently, and that the sun seldom penetrates the cloud of mist, and it is not difficult to understand why the Antarctic continent should be perpetually ice-bound and barren.

But it is far otherwise with the sea. As in the north, the surface of the ocean is rich in minute animal and plant organisms, which form the first link in the nutritive chain—through crustaceans and small fishes—on which all higher animals depend.

Whales occur in "immense schools" in the Antarctic seas. "The Scottish Expedition of 1892–3 passed through thousands of finner whales. On December 16th, 1892, many came quite close to the ship, and as far as the eye could reach in all directions one could see their curved backs and hear their resounding blasts." They are much hunted, but as they go well in among the pack-ice there is some hope that they may not be soon exterminated.

Seals, too, are abundant, especially the species known as Weddell Seal, which frequents all Antarctic shores. The great Sea-elephant is sometimes seen among the ice, but it has a wide range and is not strictly a polar animal. Another very characteristic seal is the agile sea-leopard, which is able to prey on the penguins, catching them as they swim, and dragging them down under water.

The Antarctic Continent proper has no resident land birds, and only one, the sheath-bill, is known to reach it as a migrant. But wherever the cliffs and shores are free from ice and snow they are peopled in summer by incredible hordes of sea-birds. Skuas, the great Antarctic robbers that prey on the eggs and young of other birds, gulls, terns, and at least one kind of cormorant are known to occur, but by far the most numerous are the Petrels and the Penguins.

The petrels make their nests for the most part high up on precipitous cliffs. There are many kinds of them. The dainty little Snowy Petrel, which is about the size of a swallow, is at home all round the Pole, and the early explorers regarded its presence as a sure sign that they were coming near the pack-ice. The Giant Petrel, known to sailors as the "Nelly" or "Stinker," is, like most of the order, a strictly oceanic bird, feeding, resting, even sleeping in the open sea, and only visiting land for the few weeks of the breeding season. It is a bird of powerful flight, and will follow the whaling vessels for long distances to gorge itself on the blubber and refuse. The beautiful big "Cape Pigeon" (*Daption capensis*), also a petrel, nests high up on the cliffs of the Antarctic Continent and of many of the islands. The naturalists of the Scottish Expedition estimated that there were about fifty thousand nesting on the

cliffs of the South Orkney Islands alone. Their food consists mainly of small crustaceans, and they, too, quickly gather about a vessel when a whale is killed, the attraction in this case being the small animals known as " whale-food " which are cast up in masses by the dying monster. The Cape Pigeon, like other members of its family, has, Dr. Bruce tells us, " the habit of ejecting from its tubular nostrils a red, oily, foul-smelling fluid composed of the half-digested remains of crustaceans." The birds can squirt this fluid to a distance of several feet with considerable precision, and the Scots explorers got their clothes drenched with it when they climbed in search of the large white eggs, which they were the first to bring home from the Antarctic regions.

PENGUINS

Most characteristic of all the birds of the Antarctic are the Penguins, and they are like nothing else anywhere in the world! It is true that their short wings, their close, oily black and white plumage, and their upright position when sitting give them a certain resemblance to the guillemots, razorbills and other auks of the North, but this resemblance is purely superficial and does not extend to details of structure.

The penguins do not fly at all. Their short, flipper-like wings are movable only at the shoulder-joint and are covered entirely with small, somewhat scale-like feathers. These flippers are used in swimming and diving, and have a rotatory motion somewhat suggestive of paddles.

On land the penguins are awkward, for their legs are enclosed in skin down almost to the rather clumsy foot, and their bodies are top-heavy so that they toddle along like fat babies " one hundred and thirty steps to the minute, six inches to the step, two-thirds of a mile an hour." Every now and again they flop forward on their breasts and toboggan along for a little, using their wings as they do in the water, and their legs as propellers. " No living thing I ever saw expresses so graphically a state of *hurry* as a penguin when trying to escape. Its neck is stretched out,

flippers whirring like the sails of a windmill, and body wagging from side to side as its short legs make stumbling and frantic efforts to get over the ground. There is such an expression of anxiety written all over the bird, it picks itself up from every fall, and stumbles again with such an air of having an armful of bundles, that it escapes quite as often by the laughter of the pursuer as by its own really considerable speed."

But in the water they are incomparably agile. They swim by means of their wings alone, using their legs, except at the very surface, only as a rudder. With their lungs filled with air they dive down, it may be ten feet, after a fish which they catch and swallow under water. They rise to the surface again, turn on one side and "in sheer playfulness and excess of joy beat the water with the uppermost wing, wriggle about, then turn over and splash with the other."

The largest of the penguins is the Emperor (*Aptenodytes forsteri*), which weighs about eighty pounds and stands, when erect, from three and a half to four feet in height. It is less numerous and widespread than many of the smaller species, but large breeding colonies may be seen year after year in certain localities. The Emperor penguin differs from all others in that it arrives at its breeding-places in mid-winter and lays its eggs on the bare ice. It is then transferred to a pocket formed by a loose flap of skin that hangs over a bare patch on the lowest part of the body, and thus covered it lies upon the feet of the parent bird. The chicks are protected in the same way, but notwithstanding this remarkable adaptation the mortality due to weather conditions is very heavy.

The "jackass" penguins, so called from their habit of braying, make a burrow in which to lay their eggs. In inacessible places the burrow may be just deep enough to cover the bird, or may even be only a depression under a tussock of grass or an overhanging ledge, but where, as in the Falkland Islands, the birds are liable to be molested they may tunnel as far as ten feet underground. How they dig does not seem to have been observed, but it is probable

that both bill and feet are used. The jackass penguins begin to bray as soon as the young are hatched, and continue to do so incessantly from sunset to sunrise until they leave for their winter quarters.

A fine account of the breeding habits of the penguins has been given by Dr. Murray Levick, of the *Terra Nova* Expedition. It applies to the Black-throated or Adélie penguin (*Pygosceles adelia*), which is one of the smaller species, and is also more restricted to the actual ice region than some of the others. Dr. Levick's observations were made at Cape Adare, where the birds began to arrive about the middle of October, at first in twos and threes, but soon in ever-increasing hordes, until by the end of the month the rookery contained about three-quarters of a million birds. When they have landed safely the hens at once betake themselves to the old nests or scoop out new hollows and sit down to wait. For a while the cocks are languid after the fatigue of the voyage, but by and by they begin to look about for a mate. Approaching the chosen one they " lay an imaginary stone at her feet." She, probably still tired, takes very little notice of her suitor until a rival one appears. A fight takes place, the combatants pressing their breasts close against each other and raining blows with their flippers, while the female looks on with mild interest. The combats do not seem to be very serious, for though the observer occasionally saw blood drawn, he never saw a cock killed in fight. The victorious bird has to spend a few days guarding his nest and driving off intruders, but by the end of the month all were mated and the birds settled down to their domestic affairs. Both birds remained at the nest, of course without food, until the eggs were laid, but then one of them went off to sea and remained away for several days, when it returned to relieve the other. After the young have emerged the parents take turn about of sitting on the nest and going to sea to fetch food. As the Adélie penguin nests, not on a flat shore but on a stony slope from 500 to 700 feet up, the transport is no easy task. Going down is easy enough; they simply toboggan with outspread " wings," the thick layer of fat under the skin enabling

them to bounce unhurt from stone to stone. But coming up again is a different matter! "During the whole of the time when they are rearing their young brood, these mountaineers must make several journeys during the twenty-four hours, to carry their enormous bellyfuls of Euphausia all the way from the sea to the young on their nests—a weary climb for their little legs and bulky bodies, each upward journey taking them some two hours of strenuous climbing." Sometimes, indeed, if they have tried to carry too big a load, the journey proves too much for them. They get sick before they reach the top, and the fruits of their labour are lost. When the laden parent reaches the nest it opens its mouth wide, and the young one thrusts its head in and helps itself. The Euphausias which form their chief food are very common somewhat shrimp-like crustaceans.

The mother penguins sit very steadily on the nests, but the cocks are easily distracted and drawn off to a fight. They often do a good deal of damage in this way in the crowded rookery, and the sitting hens scream their expostulations from all sides. The skuas, too, take toll of the chicks, and great havoc is sometimes wrought by a landslide or a sudden snowstorm. Yet on the whole the penguins seem to live a happy and successful life.

As the young birds grow up, the parents stay away longer and longer, playing on at the sea. For play they unmistakably do, tobogganing, diving, leaping out of the water, crowding on to an ice-floe and letting themselves be carried to the end of the rookery, then tumbling off and swimming back for another ride on a fresh floe. All this time the young ones are left in groups or "créches" undei the charge of staid and reliable birds who fend off the skuas and tend the chicks. The parent birds visit their offspring from time to time, each carrying food and each keeping strictly to its own créche. As the time for leaving the breeding-grounds approaches, the birds may be seen *drilling* in thousands on the ice—executing ordered movements for hours at a time. This is a preliminary to the autumnal journey northwards to the unknown winter quarters, and in a short time all the

penguins have disappeared again into the mist and blizzard whence they emerged in spring.

There is a peculiar fascination in the life of penguins—their winglessness, their gregariousness, their parental care, their games, their exploits in swimming, diving, climbing, and tobogganing, their southward migration to breed on the Antarctic Continent, their winter quarters in the open sea. But the biggest fact is simply that they have found very difficult haunts both for summer and winter, and have achieved highly successful adaptation. Although they have lost the power of flight—a loss that is apt to be fatal to birds, as in the case of the Great Auk—they hold their own very effectively, and would show no diminution in numbers if man did not harass them so ruthlessly. This is part of the perennial charm of Natural History: to see animals living dangerously, yet triumphing in their adventures.

THE STORM-PETREL

Amongst the jetsam which November gales toss up on the beach we sometimes find a battered Storm-Petrel, and once we found its cousin the Fork-tailed Petrel which had met a similar fate. From their breeding-places, which are often on islets to the north and north-west of Scotland, Storm-Petrels migrate in autumn to the open sea, where they spend the winter. It is probably during these migrations that some of them go astray in stormy weather, and are killed against the rocks. More independent of the earth than almost any other bird, for they rarely touch it except at their nests, the petrels are often wrecked in the end.

They get various names, these creatures of the open sea, smallest and daintiest of our web-footed birds, one of the best known being Mother Carey's Chickens, which is supposed to suggest that the Mater Cara, who has the weak and storm-tossed in her keeping, has a kindly interest in the adventurous petrels. And as to the word petrel, it is supposed to refer to St. Peter's attempt to walk on the water.

The Storm-Petrel is a sooty black bird, with a little white

about the tail and under the wings, just over six inches in length, with long, somewhat swift-like wings well suited for rapid flight, and with long legs, the meaning of which is obscure. That its affinities are with albatross, shearwater, fulmar, and the like, and in nowise with the gulls, in spite of superficial resemblances, is indicated by the fact that the



Photo: W. S. Berridge, F.Z.S.

STORM PETREL (*Procellaria pelagicus*).

Colonies of the Storm-Petrel, or "Mother Carey's Chicken," as it is often called, are found in the Shetland and Orkney Islands, and islands off the southern coasts of Wales and north and western coasts of Ireland; it also breeds abundantly in the Scilly Islands. The eggs are not laid until the middle of June, and the period of incubation is extraordinarily long. The young take more than ten weeks to become fully fledged. The petrel family is well represented in the Antarctic.

horny bill is made up of numerous pieces (taking our thoughts back to reptiles' scales), by the extension of the two nostrils into a double external tube, by the single chalky-white egg with a few reddish-brown spots, by the very long sooty-ash down covering the nestling, and by many deeper characteristics.

The Storm-Petrel has become a thoroughgoing pelagic bird; that is to say, it keeps to the open sea except at the

nesting-time. It has actually been seen flying across a promontory and hawking insects like a swallow, but this is not typical. Usually it flies close to the waves with its web-feet touching now and then, or paddles about floating on the surface. Its food consists of small fishes, crustaceans, molluscs, and other open-sea animals, and at the nesting-time it seems to be fond of morsels of sorrel. The crop contains a good deal of oil, which the bird vomits up forcibly when suddenly molested. It is also given by both sexes to the young. A captive Storm-Petrel was fed for three months on oil alone. The amount of oil throughout the bird may be inferred from the fact that some islanders thread a wick through the dead body and use it as a lamp, "the excess of fat burning steadily until the whole is consumed."

The Storm-Petrel's nest hardly deserves the name; it is never more than a little mattress of dry grass. The single egg is laid (about the end of June in Scotland) in a hole among the rocks or loose stones, or in a burrow, which may be a rabbit's, or may be partly made by the bird's own exertions. There is a pervasive musky smell about the hole. The parents seem to share the patient duty of brooding, and this lasts for about five weeks. During that time the birds are not seen coming or going, for they become crepuscular in their habits. After the young bird is hatched it seems to be left alone during the day while the parents recuperate at sea and collect the oil for the heavy supper which their nestling makes, and needs. It is not till the autumn that the young birds are able to leave the hole and fend for themselves, and such a prolonged infancy would not be possible were not the nesting-place well hidden.

There is no doubt that the Storm-Petrel belongs to a family of ancient birds, with a long pedigree going far back to some affiliation with the extinct, giant, toothed Diver of the Cretaceous times. Like its relatives, it has held its own by becoming highly specialised in its everyday habitat and in its way of feeding on surface pelagic animals. It is very interesting to find among its relatives a Diving Petrel (Pelecanoides), remarkably but deceptively like a Little Auk,

which has become a most expert diver, disappearing instantaneously, swimming swiftly with its wings under water, and emerging again *in flight*—a brilliant instance of the way in which survival is secured by trying every niche of possibility. A great part of organic evolution has been a continual obedience to the precept : Test all things and hold fast that which is good. There is in many living creatures a quality of inventiveness, of more or less intelligent but always strenuous experimenting, which enables them to evade the closing net of environing difficulties. Often, at least, their reward is survival through originality.

THE GANNET

We take the Gannet (*Sula bassana*) as a type of Open-Sea bird, for its summer stations, like the Bass Rock (to which it owes the name bassana), Ailsa Craig, Bressay, and Sulis-kerry, are breeding-places, not homes. A few " old stagers " may be seen at these breeding haunts in winter, but the great majority migrate to the open waters of the North Atlantic. A number find their way into the Mediterranean and the Gulf of Mexico. An interesting point is that there are now only fifteen breeding stations, and that six of them are round the British coasts. The gannet, or solan goose, is the only British representative of its family (Sulidæ) ; it is related to Tropic Birds, Frigate Birds, Cormorants, and Pelicans, but not in any way to geese.

Among structural peculiarities may be noticed the closing of the nostrils to a pinhole, the vestigial state of the tongue, and the inclusion of all the four toes in the web. There is a curious comb-like serration of the claw of one of the toes, comparable to the " pectination " seen in nightjar, heron, bittern, and some other birds, but its significance is uncertain. More interesting is a forward tilting of the coracoid bone of the shoulder-girdle, so that it is almost in a line with the axis of the breastbone. This makes it easier for the bird to stand the impact of its terrific dive. Another peculiarity, very well known but not very clearly understood, is the presence of a large number of air-sacs underneath the skin. They are in

connection with the internal air-sac system characteristic of birds, and can be inflated or emptied from the lungs. They form a layer of air-cushions over the greater part of the body, and are very conspicuous when one skins the bird. They were studied long ago by Sir Richard Owen, Professor MacGillivray, and others, but their meaning is not quite certain. They make the heavy body more buoyant when the bird is floating in the stormy sea ; they may serve to lessen the shock of the great dive ; and we venture to suggest that they may have some use in winter in lessening the loss of heat into the cold water. It must be understood that they represent an exaggeration or great extension of the ordinary air-sac system, but there is a curious suggestion of a diseased state in man known as emphysema, a puffy condition due to the diffusion of air into the connective tissue. Lastly, it must be noted that a similar superficial extension of the air-sacs is seen in hornbills and screamers, whose habits are very different from those of the gannet.

Every creature is a bundle of adaptations, and we are not nearly at an end of the gannet's. But it may be enough to notice one more—the long, strong, sharp-pointed bill with a row of fine backward-directed serrations along the inner edge. Nothing could be better for gripping fish.

Gannets are hungry birds, and do not obey hard-and-fast rules ; but there is no doubt that they seldom catch anything but fishes, except an occasional squid ; that they prefer full-grown herring and mackerel and the like ; and that they look out for shoals, for that makes fishing easier. As their booty is moving even as they dive, we can understand the importance of not closing the wings till the last moment in the descent. It sometimes happens that they swallow somewhat difficult fishes like the gurnard—a thorny subject. This may be fatal. Dr. F. M. Ogilvie notices that gannets, like some other Open-Sea birds, suffer severely in prolonged stormy weather, for the fishes are driven beyond their sight and reach. " There is no bird, to my mind, that seems so full of vigour and the joy of living, when the world goes well with him, as a gannet, and no more pitiable sight than the same bird buffeting up against the relentless 'north-easter,'

struggling on without food, without strength, and finally falling exhausted and being washed up by the incoming tide." On the other hand, the gannet has no living enemies except man. It may be that the bird's custom of accumulating malodorous heaps of disgorged fish near the nest is the beginning of a storing instinct. For were there not some food in reserve a prolonged storm would involve the nestlings as well as the parents in disaster. That brings us to family matters.

First of all there is the courting, of which a careful description has been given by Mr. F. B. Kirkman. Gannets are monogamous, and probably pair for life, for they are seen arriving in pairs at the breeding station. They have an elaborate ceremonial, wagging their heads, knocking their bills together like castanets, whetting one bill against the other, cosseting one another's plumage with their bill-tip, bending and bowing, and uttering strident cries, "Urrah, urrah." The males and females are alike in appearance, and behave in the same way. The ceremonial does not stop with the courting, but continues into the brooding chapter, and is exhibited when one bird relieves the other at the nest. Very remarkable is Mr. Kirkman's account of the ceremonious way in which the bird that has been sitting proceeds to leave the nest and the ledge of the cliff. It rises silently, stretches neck and beak up to the sky, raises its wings more or less erect, depresses the tail, walks stiffly to the edge of the shelf, and launches itself into the air with a strange cry never uttered on any other occasion. There can be little doubt that the gannet is a very affectionate bird, and this is not inconsistent with a strange roughness which mates sometimes display to one another or with their snappiness to their next-door neighbours. There is considerable bickering on the craig.

The gannet stakes the continuance of its race on one egg per annum, which shows that its position in the struggle for existence is fairly secure. The shell is greenish-blue, covered by a rough, chalky layer, which is often stained. Before sinking down on the sparse collection of seaweed and flotsam that forms the "nest," the brooding bird puts its webbed feet over the egg and keeps them in this position.

The incubation lasts for six weeks—an unusually long time—and the bird that is sitting is not easily disturbed. It may lunge at you with its bill, but it sits tight. It is perhaps the gannet's indifference to man's presence that accounts for the name "booby" (Portuguese for fool ?) applied to some other species of Sula, for the bird is anything but stupid.

The newly hatched gannet is blind and naked and slate-coloured; but it is soon covered with beautiful white down. It is abundantly fed and becomes very fat, which may make for safety by inducing a sluggish disposition. For the ledge of a sea cliff is not a suitable place for juvenile exercises. In about three months the youngster is ready, but not very willing, for its first plunge. The prolonged feeding means a good deal of work on the parents' part, but they share responsibilities equally both in sitting and foraging. In early days they prepare pulpy packets of half-digested fish, sometimes thrown up and re-swallowed, and the young bird gets possession of these by thrusting its head into the parent's widely opened mouth. Later on, the young bird takes fresh fish from the adult's crop, thrusting in the whole length of its head and neck. It must be a great day when the young gannet first catches a fish for itself. They are not mature for three or four years, and exhibit as they grow an interesting series of plumages. As the immature birds are seen among the adults on the breeding stations they have opportunities for picking up hints which may be useful additions to their heritage of instincts. For even a booby can learn.

SWALLOWS

As every one knows, there are three swallows, summer visitors to Great Britain, and the order of their coming is usually sand-martin, swallow, and house-martin. It takes the three of them to make a summer. The sand-martin is smallest, quickest, jerkiest of our three swallows, known at a glance by being brown above and white below. It hawks for insects over the ponds and lochs, and nests in the burrow which it has excavated, sometimes for a yard, in the face of a sand-pit or river bank. Its short beak does not look

like a digging instrument; it is helped by the toes, which scratch out the loosened earth. There are not very many birds that burrow! Sand-martins are cheerful, sociable creatures, fond of clinging in quivering flocks to the face of the pit or cutting, fond also of aerial evolutions, especially after they have left their nests—no longer very wholesome—and are congregated among the reeds and osiers talking eagerly about nothing.

The house-martin is familiarly marked by the splash of brilliant white on the rump, the rest of the upper surface being steel-blue, and by having the under parts white. Mr. Kirkman says very prettily that when the bird flies away over the unruffled surface of a lake or river, "there are two white spots to be seen, one speeding through the air, and beneath it another, the reflection of the bird's under parts speeding through the water—twin stars that vanish imperceptibly." Very characteristic also are the house-martin's white gaiters.

There can be no doubt that the house-martin's original nesting site was the face of a cliff under a protecting ledge; and many of them still build in such places. Thus we understand why the nest, unlike the swallow's open half-saucer, should be a half-cup, closed save for the small door near the top. The half-inch walls of hardened mud are built very gradually, interlaced a little with straw and hair and perhaps mixed with some saliva. There is a lining of feathers and bits of grass. In the quite unrelated cave-inhabiting sea-swifts (Collocalia) of the Far East, the edible nests which the Chinese dissolve into costly soup are made of the mucin secreted by the bird's large salivary glands and are naturally very digestible. They look like half-saucers of frosted sugar, but when a couple of nests, made in succession, have been collected for exportation to China, the bird has to fall back on seaweed, for the supply of salivary juice becomes exhausted. As we have said, the sea-swifts have nothing to do with the swallows, but the latter have also abundant saliva, and it would be interesting to know if they use it in nest-building. The primary use of the glutinous secretion in all these cases is probably to help in the entanglement

and compacting of insects within the mouth. The parent house-martins feed their nestlings—two of them at a time—every few minutes. They thrust their beak into the young one's mouth and deliver a mass of confused feeding. Perhaps they account for at least a thousand insects apiece in the course of a long summer's day.

The swallow is such a beautiful bird that one could wish it a finer name. There is probably no reference to its gape, but "hirondelle" seems more fitting than "swallow." The adult male is steel-blue above, save that the forehead is chestnut-red and the outspread dark green tail-feathers show long oval white spots. The throat is chestnut again, and then comes a band of blue; the rest is light buff except the chestnut of the under tail-coverts. The female is nearly as handsome but not quite. But the fine coloration is almost lost sight of in the beauty of the movements—such a complete mastery of the art of flight that we cannot wonder at Athene once taking the swallow's form. A characteristic feature is the length of the wing, especially of the primary feathers, "every one of which," Ruskin wrote, "may be briefly described as the strongest scimitar that can be made of quill substance; flexible within limits and elastic at its edges—carried by an elastic central shaft—twisted like a windmill sail—striking with the flat, and recovering with the edge." The tail is more delicately forked than in the martins, but we must think of the long wings as responsible for almost all the aerial steering.

Ruskin speaks of the swallow's mouth as "a net for the catching of gnats," but that suggests a bird flying with its mouth open, which is not true even of a goatsucker. The swallow, like its relatives, snaps at flying insects, and the glutinous saliva in the mouth keeps previous captures from escaping. Gilbert White noticed that swallows were able to drink from the surface of the water without pausing in their flight, but they are not restricted to this method.

Ruskin's knowledge of birds was not so great as his love for them, but he sometimes hit the nail on the head. It was graphic, for instance, to point out some of the swallow's paradoxes. "Of all land birds, the one that has least to do

with the earth; of all the least disposed and the least able to stop to pick anything up; what will it build with? Gossamer, we should say—thistledown—anything it can catch floating like flies. But it builds with stiff clay." It revels in space and freedom. "You would fancy its notion of the place for a nest would be the openest field it could find; that anything like confinement would be an agony to it; that it would almost expire of horror at the sight of a black hole. But its favourite hole is down a chimney."

The swallow is not narrow-minded in its choice of a nesting site; but it likes a roof over its head. One may perhaps say that it prefers insides, just as a house-martin prefers the outsides of buildings. But both were at the nesting business long before there were any human dwellings, and the biological explanation is simply that house-martins were originally cliff-nesters, and swallows originally cave-nesters. Preferably with something in the way of a supporting bracket, and always beneath some sort of roof or ledge that will keep the rain off, swallows build their substantial half-saucers of coherent mud. There is ease and apparent pleasure in their constructive genius.

Some British-born swallows fly south as far as Natal and Cape Colony—a long distance for a small bird. We have seen them in autumn resting for a while on a liner steaming northwards from Cape Town, and then starting again upon their southward journey. It has been proved up to the hilt that they sometimes return to their northern birthplace, even to the same building, and to the old nest. It should be noted, however, that when swallows return early they usually spend some days near water and away from buildings. This leaves time for exploring the neighbourhood and may facilitate the rediscovery of the old chimney! There are usually two broods of swallows, about five in each; and this seems to be necessary to compensate for the mortality during the migratory journey and for the assaults of sparrows and other enemies. When we think of the vitality of the swallow and its *joie de vivre*, the outcome of ages of stern sifting, we see part of the meaning of Goethe's saying that death is one of Nature's devices for securing abundant life.

THE WHEATEAR

Another of the ever welcome "summer visitors," that come to Britain in spring, is the wheatear. It returns from the South in March and continues coming—wave after wave—until the middle of May. But the last waves seem mostly to consist of a large variety, the Greenland Wheatear, which is only a bird of passage in Britain, and does not nest till it reaches the Faeroes, Iceland, and Greenland. Our wheatear is a welcome herald of the spring, one of the first of the migrants to come back to the old home.

It is a satisfactory bird because every one can recognise it at a glance by the dazzling white rump to which it owes its name. This is very conspicuous when the bird flies, and it is shown by both sexes. As the wheatear is harried by hawks, some naturalists have suggested that the white flag may serve to distract the hostile aim from more vulnerable parts. But the white splash must also be a dangerous advertisement, and we should think that safety was mainly secured by the bird's cleverness in hiding itself in a bush or in a burrow, and also by a certain unexpectedness in the restless flight. At frequent intervals it turns and twists in the air in a very adroit fashion, partly to catch insects, no doubt, but partly perhaps because jerky movements are disconcerting to enemies. But we need not wrinkle our brows trying to find far-fetched uses for such features as the wheatear's white rump. The probability is that its beauty is its only meaning.

Another satisfactory fact about the wheatear is that it always tells you it is there. For as it nods to you from a stone, flirts its tail and flies restlessly hither and thither and back once more, it says *chack*, *chack*, over and over again in a very emphatic and cheerful way. Its note is like the stonechat's, but a little different, and the two birds often frequent the same rough and open places, with outcropping stones and plenty of gorse. So the wheatear is sometimes called stone-chat, which is a pity, for the two birds are very different in appearance. As a matter of fact, however, the wheatear and the stonechat are second cousins, and members of the same thrush family. Both have the "chack" danger-signal, like

that made when two stones are clapped sharply together, but the wheater has a much finer song, in which he often mingles notes and phrases borrowed from other birds. He has good taste of his own, but he cannot refrain from plagiarism. Perhaps the end justifies the means, for all is fair in love.

It is very difficult to understand why the wheatear should be regarded in many parts of the country as a bird of ill-omen, especially if it says "chack, chack," when seated on a stone, which is just what it usually does. Can it be merely that the bird frequents lonely and wild places, where the open spaces get on the nerves of the timid? They hear in the "chack, chack," the sound of the mason carving their name on a tombstone! What a conceited idea! The facts are all against the superstition, for the wheatear is a buoyantly cheerful bird. It says, "chack, chack," but it is unafraid: the cock-birds court with gaiety, and fight with zest; they often sing not only as they fly, but as they fight, which surely proves their high spirits.

The way in which wheatears accompany one across a moor, flitting from boulder to boulder, always keeping a little way ahead, shows alertness, but no timidity. Professor Newton wrote: "The cock with his bluish-grey back and light buff breast, set off with black ear-coverts, wings and part of the tail, is rendered still more conspicuous by his white rump as he takes short flights in front of those who disturb him, while his sprightly actions and gay song harmonise so well with his delicately tinted plumage as to render him a welcome object to all who delight in an open country." That strikes the right note; the wheatear is constitutionally, that is to say at heart, a very cheerful bird.

The male wheatear sings to his desired mate and shows off before her, both on the ground and in the air. There is unusual "abandon." As Miss E. L. Turner says: "He seems positively drunk with the joy of life." There are excited combats among rival males, but they do not seem to do one another much hurt.

The nest is often made in a rabbit's burrow or in any similar hole. It is a loose cup of grass and roots, quilted with rabbit's fur, sheep's wool, or any similar material. There

are about six pale-blue eggs, which usually hatch out in May. The cock-bird helps in nest-making, and a little in brooding. Both parents, themselves insectivorous (including small snails among insects !), collect spiders, caterpillars, moths, and the like for the nestlings, who keep well in hiding. The food is often pounded into pulp before it is given to the young ones.

THE CUCKOO

Certainly the cuckoo is an enigmatic bird—a bundle of incongruities. It is almost unique in not making any nest, for, although some of the unrelated American cow-birds also shirk this, there are others of them that fall into the traditional and respectable line. It is a strange fact that one kind of cow-bird that shirks brooding altogether actually utilises the nest of one of its cousins which is true to the nesting and brooding instinct. As for mound-birds, which lay their eggs in hot-beds of fermenting vegetation and the like, it would not be fair to regard them as evading parental responsibilities. Their young ones, effectively pre-arranged for, are able to wriggle out of the mound, and to run, if not to fly, on the day on which they are hatched.

The cuckoo is also unique among our British birds, inasmuch as the adults leave our shores before the young birds are ready, preceding them by six weeks or more. In all other cases, the youngsters are the first to go. This peculiarity is no doubt wrapped up with the fact that the adult cuckoos feed very largely on hairy caterpillars, and have to migrate when the supplies give out. But their offspring are fed by the duped foster-parents.

The cuckoo has other peculiarities, which could, no doubt, be unified, if we were better biologists. The female lays her eggs at unusually long intervals ; the egg is small for the size of the bird ; the female is polyandrous, that is, it has many husbands, the males being in a great majority. There is also some deep constitutional peculiarity in the young cuckoo, for during its early youth it is extraordinarily sensitive to touch—it is thrown into convulsive fits when one of the rightful tenants of the nest in which it is hatched

touches the small of its back. It writhes and jerks—an inborn "dog in the manger"—and instinctively ejects its neighbour from the nest. The young cuckoo is big for the nest in the great majority of cases, and its treatment of its neighbours is just an instinctive attempt to make room. We know some children who cannot bear to be touched, and the young cuckoo hatched in its foster-parents' nest is one of these "touchy" creatures. After the first eleven days, they say, the exaggerated touchiness wanes.

Until recently, the general view of ornithologists has been that the mother-cuckoo lays her egg on the ground, takes it in her mouth, and flies down the hedgerow or over the meadow until she espies a suitable nest, say, of a hedge-sparrow or a meadow-pipit, into which she places her egg, and thinks no more about it. Many good observers have, we believe, seen the cuckoo laying on the ground, taking the egg in her mouth, and depositing it in the foster-parents' nest—which is probably selected with great care before the actual deposition of the egg takes place.

Miss Hilda Terras, in her delightful *Story of a Cuckoo's Egg* (1920), writes: "I saw a bird suddenly sail quickly down from the roof above me, and fly on to the hedge about two feet from the nest. It was the cuckoo. . . . There it sat, nervously turning its head this way and that, and looking about it in the same stealthy, cunning way that it had done on the occasion of its previous visit. I could almost swear it was saying to itself anxiously, 'Are they looking? No, thank goodness, I've done them at *last*!' And then, without any hesitation, it hopped straight into the hedge and disappeared from view. For about a minute it was there; then it came out and flew away. Burning with curiosity, I hurried into the garden, and, eagerly parting the branches of the hedge, looked into the nest, and lo and behold, there, lying in Henrietta's (the hedge-sparrow's) dear cup-shaped, softly-lined home, I saw the cuckoo's egg! One of my sisters had again watched with me, and once more we were amazed at the positive uncanny sagacity of the bird. The whole thing seemed so extraordinarily intelligent, and so *mean*!" We have quoted the account

because we believe it to be true and typical. The mother cuckoo lays its egg on the ground, takes it completely into its large mouth, flies to a previously selected nest, and pops it in.

But this does not in the least prove that there is anything wrong in the account which Mr. Edgar Chance has also given of this strange business—an account substantiated by a beautiful and continuous film of the mother-cuckoo's behaviour. Mr. Chance found that the cuckoo *laid* its egg in the meadow-pipit's nest, and that it removed and devoured the foster-parents' eggs. There is likely to be variability in these relatively modern subtleties of instinctive behaviour, especially in a case like the cuckoo's, where a want of time-keeping between the normal chapters has set in, and we do not doubt that Mr. Chance observed an egg-laying. He is not the first to make this suggestion, and Raspail speaks of the mother-cuckoo removing and destroying an egg from the foster-parents' nest. But we should not like to generalise from Mr. Chance's fine observations, and that for several reasons. A number of good observers have seen the mother-cuckoo take her egg in her bill. She sometimes stays at the foster-parents' nest for a very short time—far too short for egg-laying. There is in the famous "Fenton Collection" of eggs in the Aberdeen University Museum, a cuckoo's egg from such nests as a swallow's, a reed-warbler's, and a tree-creeper's, in which she could not lay it. In Pomerania, we think, one of the commonest hosts is the wren, and we cannot picture a cuckoo laying its egg in a wren's nest. Therefore, and for other reasons, we believe Jenner's old account of the business is in the main correct, for the majority of cases.

THE PARTRIDGE

Unlike the pheasant, the common partridge is a native of Britain, but its range extends as far as the Ural Mountains and Siberia. It must, therefore, be called a very successful bird, and we wish to ask why.

One reason is to be found in its cryptic coloration. How

inconspicuous it is on a ploughed field or even among the stubble. Its plumage is as protective as it is beautiful. The main colour is slate-grey, but this is shaded with black hair-lines and barred with chestnut and buff. There is a good deal of chestnut about the head and throat, and there is a chocolate crescent on the breast. It is worth while peering into the colouring to see how subtle it is, and then one discovers that there is no small degree of individuality. This suggests that the partridge must have a firm foothold in the struggle for existence, for when a creature is still insecure, variations from the profitable form of colouring are nipped in the bud. But our point is that the partridge has its share of the cloak of invisibility, and yet it is one of the most beautiful of British birds. For practical purposes the two sexes are the same in plumage.

The partridge among the stubble is deceptively like a clod, and the protectiveness is increased by the habit of lying low. The birds crouch or squat till we are almost on them. Then comes the explosion—a startled cry and the whir of the rapid wing-strokes. There is safety in the rapidity of the flight, though it cannot be kept up for long. The strong development of the breast muscles which work the wings, is familiar to all who have the good fortune to enjoy cold partridge; and the roundness of the short wings is characteristic of birds that put on a very rapid spurt. As the birds rise we may notice the outspreading of the tail, which has always eighteen main-feathers, the outermost of a chestnut colour. And as the birds get tired we may see them "resting on their oars"—and what is flight but rowing in the air?—for they glide along with their wings outspread, and slightly drooping.

Like many other successful creatures, the partridge has a long bill of fare; and it is obviously a great advantage to be able to utilise a large variety of food-materials. We may mention the tender shoots of grass and corn, the tips of the young clover, the ends of the heather twigs, the fruits of the blaeberry, many kinds of seeds, occasional plump spiders, and numerous insects, not forgetting injurious caterpillars. The young partridges or "cheepers" have to be fed on

insects, and they continue to be fond of them after they begin to fend for themselves. It may be said that the common partridge thrives where agriculture flourishes, and they do good as well as harm, though not very much of either.

From February till winter comes again, the partridges are in pairs, or, later on, in family parties. But in winter there is often a combination of families into large coveys, and this gregariousness must afford some protection against enemies. Union is strength. They are said to sleep in circles with their heads turned windwards, and this will make a surprise attack more difficult.

When the coveys break about the end of February the mating season begins, and this means some liveliness. The males challenge one another, calling loudly and jerking up their tails. They have excited tussles, fighting with feet, wings, and beak. But there is much cry and little wool; the assaults do not involve any bodily injury. The hens run round the combatants as if they enjoyed the fray, and we are not sure that they do not fight also. Perhaps they have something to say to the minxes who were making eyes at their husbands. For the fighting goes on after the partridges have paired. Perhaps it is safe to say that the honeymoon period is prolonged, for the serious business of egg-laying does not begin till April or May, or even later. Once the birds have settled down to matrimony, they are faithful to one another. In other words, they are monogamous, which is more than can be said of many game-birds.

The nest, hidden among herbage, is a hollow lined with grass and leaves. It is often in a hedgerow or near the margin of a wood. There may be ten to twenty eggs, usually olive-brown or grey-olive, often far from conspicuous in their natural surroundings, often hidden by the leaves of the nest if the mother-bird has left them for a minute. But she is well known to sit very close, and she has the somewhat puzzling power of suppressing her natural scent during incubation. Even an experienced dog will pass close to a brooding partridge; so long as he does not see her, she is safe. The suppression of the scent requires further investi-

gation. It may be that the oil-gland at the root of the tail, which produces an odoriferous ointment in many birds, passes into a condition of temporary inactivity during the brooding, perhaps because of some subtle chemical messenger or hormone. It may be that the mother-bird is fasting. But facts are needed rather than theories.

The brooding lasts for twenty-two to twenty-four days, and though the cock does not share, he is not far off. He stands on guard, and if the worst comes to the worst he can sound the danger-signal and fight. Good observers have noticed that when the day of hatching arrives, the cock-bird comes as close as possible to his mate and assists her by drying the young ones as they are hatched out. Both parents are very brave in defence of their fascinating offspring. They will attack hawks, crows, stoats, dogs, and even man himself. They are clever in covering the retreat of their brood, and have been seen "feigning injury to distract attention." At an earlier stage they have been known to remove the eggs to another nest, carrying them, we suppose, one by one, in their beak. What usually happens is that the parents utter a characteristic note, which the buffish-brown young ones instinctively obey. They scatter and become invisible. When we think of the number of the eggs, the close brooding, the parental courage, the filial obedience, we understand more clearly why the partridge is a success.

THE PHEASANT

It is a feast for the eyes to watch the cock pheasants picking corn among the stubble, in the low autumnal sunlight. Exuberant is a fit word for their gorgeous beauty of red and orange, grey and green, yellow and purple. Pheasants are aristocrats among fowls, winning our esteem by their decorative handsomeness rather than by their brains or by any force of character.

The *Common* Pheasant—if one may say "common"—is a native of Asia Minor and the shores of the Caspian Sea. It is still a wild bird there, but in many parts of the world it now flourishes under man's shield. Yet it refuses to become

domesticated. It may be tamed, but it remains itself and no other. It does not produce such a copious crop of variants as the Common Fowl, and it will not surrender itself, as that plastic bird has done, to man's wishes: *e.g.*, in the matter of laying eggs more or less all the year round. As the illustrious Charles Waterton says: "Notwithstanding the proximity of the pheasant to the nature of the barndoor fowl, still it has that within it which baffles every attempt on our part to render its domestication complete." What the difficulty is we cannot at present define—there is *some lack of plasticity*. The same is true of many other creatures; thus we do not suppose that any one would claim the ostrich as domesticated. How truly wild most hive-bees remain! Waterton thought that what persisted in the pheasant was an "innate timidity" which expressed itself whenever anything unexpected happened. On the other hand, cock-pheasants may become almost embarrassingly tame; they have been known to attack the squires' ladies when the fashion of the day—*e.g.*, crinolines—pulled the trigger of their fury.

The probability is that the Romans introduced the pheasant into Britain and into other European countries. In modern times it has been established far and wide; *e.g.*, in New Zealand and North America. What it likes is a wood with abundant undergrowth, affording not only shelter but a varied diet of fruits and seeds, shoots and roots. In the struggle for existence it is always an advantage to have a varied bill of fare. If one item fails, another may be available. Omnivorous creatures always have an advantage over the specialists in diet. The pheasant, like the common fowl, has a long menu; in fact, almost everything is grist that comes to its mill—as the gizzard may well be called. Even pebbles are of use. Pheasants eat grain, seeds, fruits, buds, leaves, roots, flowers, insects, larvæ—what not? There is no use blinking the fact that they are very fond of grain, but it is equally unfair to forget that they account for enormous numbers of wire-worms and other injurious insects. Among the strange items on their bill of fare are mice, adders, oak-spangles, hazel-nuts, acorns, polypody-

fern, and bracken. Pheasants are, we must admit, rather fond of the table, and we cannot think that stuffing the crop with ferns is an indication of intelligence! But if they would form a habit of eating *bracken*, then the hill-farmer at least would give them his blessing. For the bracken is a serious enemy of upland pasture.

The pheasant's wings are not large in proportion to the size of the bird, but they are broad and rounded, and the wing-muscles, as we know on a feast-day, are strongly developed. The whirring flight is very rapid, and we have known of a pheasant crashing right through a plate-glass shop-window. This has been often recorded, and it testifies to great velocity of flight. In preserves they often become rather lazy—and why should they fly away from a congenial home?—but pheasants are among the fastest British game-birds. The experts tell us that "driven grouse with a gale of wind behind them, driven partridges late in the season, twisting as they top the fence, make hard shooting; but there is nothing more difficult than a pheasant curling at his top speed over the roof of the trees." It is interesting to notice that pheasants can swim very well, though they will not readily take to the water. As for running, they are hard to beat, and the continual scratching in the ground for seeds and small animals keeps their leg-muscles in good form.

Like most of their game-bird (or gallinaceous) relatives, pheasants are polygamous by nature. As is usual in such cases, the rival males, armed with spurs, fight with one another, the stronger driving the weaker away, and securing a larger number of mates for themselves. In so far as the weaker males are left unmated, this form of selection is obviously for the good of the race. The cock-pheasant, coming to his own, utters his crow and then claps his wings, just the opposite of chanticleer, who claps his wings and then crows. The cock-phesant's crowing is a prelude to disporting before the hen-pheasant. He poses so as to show off his good points. On the side nearest the object of his desire the wing is partly opened and depressed, the tail is expanded, and the upper surface turned sideways. There

are subtler details, too; thus, to quote from Tegetmeier's *Pheasants*, "the bright vermilion skin around the eye is greatly extended and the little purple aigrettes are erected." This is like chapter one of an evolution series which finds its climax in the courtship of the Argus pheasant, where the secondary feathers of the wing are greatly enlarged and adorned with beautiful eye-like spots. The male Argus runs about before the female, and then, suddenly pausing, raises the decorated feathers like an upright semi-circular fan. He hides his head behind the fan, so that the female gets an uninterrupted view of the extraordinary living allurement, which is sometimes suggestive of one of a skirt-dancer's devices. Two long tail-feathers are swayed about and make a rustling sound; and the gorgeous fan itself is gently waved. When the light strikes the feather-eyes from above—there may be over twenty on one vane—they stand out like ball-and-socket ornaments. It must be noted that the "eyes" are confined to the male and they are quite hidden when the wing is closed up.

In April or May the hen-pheasant makes a simple nest, almost invariably on the ground and under some covert. It is little more than an apology for a nest—a hollow scraped in the ground. Eight or nine eggs are laid—greenish-brown to greyish-green—and the hen sits close for twenty-four days. Neither in the nest-making nor in the brooding does she get any help from the cock, for this is not the way of the polygamist. The domestic cock is often extraordinarily gallant and unselfish, calling to his favourites when he has unearthed a titbit, and looking aside somewhat self-consciously as if he had no experience of what an appetite meant, but we do not know that the cock-pheasant shows any domestic virtues of this sort. There are isolated cases, no doubt, of cock-pheasants leading about a brood of young ones, occasionally even brooding, but the significance of this is not great. It probably means just this, that living creatures are variable and that the cleavage between the sexes is often far from being clear-cut. Frequently, as in pigeons, there are rather feminine males and rather masculine females. Another expression of variability—the

fountain of living changefulness that never runs dry—is seen when a hen-pheasant utilises the tree nest of a pigeon, or even of a squirrel, and succeeds in at least hatching her eggs in that unusual site. It must be remembered that in cold weather it is quite usual for pheasants to roost in trees. Yet another variation is well known to those who live in the country, namely, the sharing of the nest with two or three other pheasants. As many as thirty eggs have been found in one nest, implying three different mothers. This peculiar occurrence points the way to the multiple nest of some of the mound-birds, where one mass of fermenting herbage is utilised by several mothers. And there are other instances of social or communal nesting. Or it may happen that a partridge utilises a pheasant's nest, or a pheasant a partridge's, and here, again, we get an interesting evolutionist glimpse: what is merely a curious aberration or experiment in one animal may become established and of survival value in another. For we have seen how the European cuckoo has made a habit of using the nest of another bird.

Pheasants have many enemies, some destroying the eggs and young, as is the case with rooks, crows, and sparrow-hawks, others attacking the full-grown birds, as do foxes and stoats. Here must be noted the interesting and somewhat obscure fact that the brooding pheasant, like the partridge, suppresses her scent. As Tegetmeier says: "Dogs, even those of the keenest powers of smell, will pass within a few feet, or even a shorter distance, of a sitting pheasant without evincing the slightest cognisance of her proximity, provided she is concealed from sight." The fact is certain and its value to a ground bird is obvious; but who knows how the suppression of the scent is brought about?

THE RED GROUSE

Like the St. Kilda Wren, the Red Grouse is all British, and we cherish it—especially in the month of August, when we shoot it in legions. It is an interesting bird in many ways. It illustrates the origin of a species under conditions

of insulation. It thrives in very diverse places, where there is heather and ling, from the shore of the sea to moors of high altitude. It is able to flourish on Spartan fare, the young shoots of heather and crowberry, the mountain berries and the fruits of sedges and rushes, but it seems to enjoy a change to corn when there are harvest fields accessible. The difficult days for the grouse are when the snow is deep and continuous, and then it descends to the more sheltered valleys, or joins with its fellows in a long trek to more comfortable quarters. Its strong rounded wings give it a power of rapid flight, but this is not usually long sustained. There is considerable variability in the colouring of the plumage. Thus the experts distinguish red, black, and white-spotted males, and red, black, white-spotted and buff-spotted females; and, besides these different types there are noteworthy seasonal changes in the course of the year.

Unlike its relatives the blackcock and the capercailzie, but like its cousin the ptarmigan, which goes higher up the mountains and puts on a white dress in winter, the red grouse is monogamous. In the spring we see the cock mount on a little elevation on the moor, and we hear his somewhat noisy challenge—"*Kok, kok, kok, go back, go back.*" The hen crouches near by, and seems to be interested in what follows. Another male comes near, and then there is a fight. The rivals jump into the air and lunge downwards with their beaks, trying to get a blow in on the head. The female seems to encourage her mate in combat.

The blood-red eggs, reminiscent of the plumage, are laid in a ground-nest and the hen does all the brooding. The young birds are very precocious, and both parents lead them about in search of flies and small caterpillars. At this time the cock defends his family against intruders, and shows great courage. We have known him fly up on a low tree and give an evil-intentioned crow a buffet on the face. After youth is past, the grouse has few external enemies except the golden eagle, who probably serves a useful purpose in weeding out the relatively weaker and less wary. This will keep up the vigour of the race.

It is not known that grouse suffer from any constitutional

disease, but they have many parasites, and in overcrowded ill-fed birds some of these, especially certain minute threadworms called strongyles, may get the upper hand and cause death. In Sir Arthur Shipley's investigation of grouse-diseases, it was found that the bird carries about a "fauna" of about twenty-five parasites. "On the outside of its skin, amongst the bases of the feathers, numerous insects browse, whilst beneath the skin, in the spaces of the body, such as that of the alimentary canal, and in the cells and tissues, such as the lining membrane of the intestine, and in the blood, worms and unicellular animals swarm."

Along with its vegetable food the grouse swallows some small insect or the like (it is unknown) which contains the juvenile stage of a tapeworm, and this may be the beginning of a very serious intruder. Or the grouse, in picking a berry from the ground, may be infected with the strongyle, just as children may be infected with maw-worm by eating imperfectly cleaned vegetables or fruit that has been lying on the moist soil. The strongyle or threadworm of the grouse is so very thin and fine that it is difficult to see a living specimen, it is so transparent. It is an intruder even more serious than the tapeworm. It finds its way to the paired blind-tubes on the food-canal, which correspond to man's vermiform appendix, and there it multiplies. The trouble is that in February, March, and April the food on the moor is scarce, only a small proportion of the heather tips being fit to eat. Therefore, all the birds on a moor tend to congregate on the small areas where there is sufficient food. The soil becomes heavily infected with strongyles from the droppings, and repeated infection is inevitable. The grouse get more and more threadworms, and the soil is infected more and more thoroughly. If spring did not come with its fresh heather-shoots hardly a bird would survive

Among young grouse there is heavy mortality during the first few weeks of their life, corresponding to the remediable infantile mortality in our cites from microbic diseases like diphtheria and scarlet fever. In the case of the grouse the infection comes from microscopic spores (Coccidia)

picked up from the ground; serious inflammation of the food-canal results, often ending in death. But the trouble is that before they die the young grouse are able to infect the soil with millions of spores.

But let us turn from this dismal subject. What is of principal importance is this: that there is no constitutional disease in Wild Nature, and that *diseases* due to parasites and microbes are usually, if not always, due to man's interference. So it seems to us. Over-preserving, *e.g.*, by shooting Golden Eagles, means that the grouse standard of health is lowered because the weakly or unfit (in some form or other) are not sifted out. Most healthy animals have parasites, and so has the grouse. But a live-and-let-live policy is established between host and parasite, and the presence of the parasites seems to do little harm unless there has been some weakening of the constitution by bad feeding or lack of Nature's sifting (Natural Selection), or because of some exaggerated multiple-infection, as often happens in crowded areas.

There are big areas in Britain where, under the present state of the soil, there cannot be anything but unprofitable heather-covered moors. These are the haunts of the grouse. The shooting of the birds is an exhilarating luxury for those who can afford this sort of thing. If "big bags" and artificial "drives" could be abolished, as inconsistent with true sport, then grouse-shooting might be regarded as a lawful luxury. As far as the Red Grouse itself is concerned, things are all right, for the bird holds its own in spite of, and partly because of, the August thinning. But let every owner of a grouse-moor protect the Golden Eagle!

THE LAPWING

It is outside strict science, but one cannot help associating distinctive birds with distinctive human types. The storm-petrel is the sea-gipsy and the tern is Columbus. The golden eagle is a robber-baron and the sparrow is plebeian. It seems to us that the peewit is the joyous cavalier. Many people speak of its plaintive cry or even

of the bird's wailing, but, whatever the sound conveys, the peewit is cheerful and defiant, sociable and sometimes jocose.

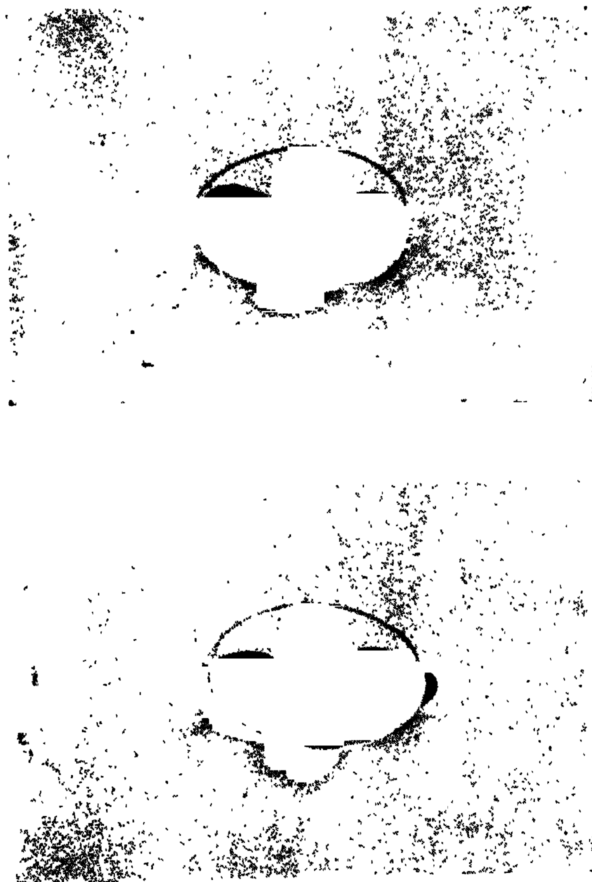
In most parts of Scotland it is represented all the year round, but it is a "partial migrant"; that is to say, some of those that were with us in summer may cross to Ireland in winter, while their place is taken by others from farther north. Some, of course, may leave our shores altogether and winter in Africa. In the wintry season in the North we have ample opportunity to admire this bird of many names—lapwing, green plover, peewit, teuchit. It is very common on the fields, very conspicuous when it flies, very much the reverse when it runs, but always graceful.

The lapwing is one of the most persecuted of birds, for its eggs are luxuries and the bird itself is often netted for the table. Yet it holds its own from Ireland to Japan, from the Arctic Circle to India. Our first question must be how the bird survives with heavy odds against it. One reason for success is a certain plasticity which enables the peewit to flourish in very diverse haunts—on the moor and on the shore of the estuary, in the farmer's fields and on marshy flats. Another reason is the considerable length of its bill of fare, for it eats a great variety of insects, such as wire-worms and leather-jackets, besides earth-worms, slugs, and small snails. Parenthetically we may recall the well-known fact that the peewit is one of the farmer's best friends. But there must be other qualities securing survival besides the variety of haunt and diet. There is the bird's great wariness, for it is difficult to take a peewit by surprise. There are the precautions for securing the safety of the eggs, and there is the young bird's useful instinct of lying low when danger threatens. There is also the gregariousness which makes it easy to drive off an intruder or an enemy. Finally, the bird is clever and courageous and cheerful. It is self-confident without being cocksure; and when we watch their gaiety in stormy weather we know that behind all their success there is a vigorous constitution.

The colours of the lapwing beggar description. It is best to look at the bird, and in spring especially, for there is

a little toning down in winter. One sees green and purple, grey and copper, black and white, and the tail-coverts are bay or fawn. All is set off by the metallic sheen, which is due to the physical structure of the feathers, and it is this that transfigures an ordinary dark pigment and gives it a green, purple, or bluish colour. The adult males and females have the same colouring, and both have got the mobile crest of six or eight feathers. It is a little longer in the male, and he has a broader and more rounded wing. The word lapwing refers to the slow flapping of the powerful wings, which sometimes suggests jerky rowing. But although the beats are slow the flight is powerful, as is usual in birds whose wings are of the broad, rounded type. Especially in migrating and in courting, the lapwing may fly at a great speed, and it is able at the breeding season to produce a vibratory or whirring sound which is due to the wings only. Many of us have heard the whir at very close quarters, when the lapwing, resentful of our intrusion, flies boldly past our face.

The courtship of lapwings has several aspects. First, there is the jealous guarding of the open place that has been chosen for nesting. As in many other birds, there is a recognition of "territory" or preserves. If another male intrudes there is a fight—an aerial combat—between the rivals. Second, there are the courtship flights, in which the birds fly far and wide, calling insistently, whirring with their wings, and tumbling extraordinarily in the air. To watch and listen is one of the delights of the spring. Third, there is an elaborate showing-off on the male's part. He circles in the air round his desired mate, who is for a fortnight or so very indifferent. He tries to excite her interest, and displays the bright buff tail-coverts. Fourth, there is a remarkable making of "scrapes" in the ground. These are made at first by the male, who scratches a little depression with great vigour, and uses it as a stage for his display. When the female's interest is roused she also may make a scrape, and her scrape may be the future nest. The male is passionate, the female is coy, and it may be that the scrapes made so energetically by the male serve to convey



LAPWING'S CLUTCH RIGHTLY AND WRONGLY ARRANGED.

The illustrations serve to show how the Lapwing arranges her eggs to economise space. In the upper photograph the eggs are set in the way in which the bird always arranges them, the points to the centre, and a wire ring is laid over them. In the lower picture the same ring is in use, while the eggs point outwards. The saving in space can easily be seen, and the "top-like" shape may be interpreted as adaptative.

to the female some subtle suggestion of a nest. For the nest is little more than a scrape in the ground with a few grass stems added. There are often two or three "scrapes" in the vicinity of the nest, and these seem to have been misinterpreted as "false nests," intended to distract the attention of enemies. It is almost certain that they have to do with courting, not with what follows.

Almost invariably there are four eggs, laid in April, with the more pointed ends towards the centre of the nest, thus economising space. The eggs are famous, like those of the black-headed gull and the guillemot, for their extraordinary variability of colouring. It is easy to get fifty different types, but the great majority are comparatively inconspicuous against the background of the soil. Both parents brood and the young are hatched after twenty-six days. There are three points of particular interest in regard to the young peewits. They are extremely precocious, able to leave the nest in twenty-four to forty-eight hours; they are often very inconspicuous in their natural surroundings; and they have a strong instinct to lie low and say nothing when the parents sound the danger signal. They are among the most charming of young birds. They are able instinctively to say something like peewit, for they have been heard uttering the call-note from within the egg! But the parents play up to their offspring. When intrusion is inevitable the female slips off the eggs and runs quietly along the ground to some distance, crouching as she runs, while the male overhead makes a great to-do and swoops down on the enemy. When the young are hatched and out of the nest, the two parents unite their efforts in trying to distract attention, and they will even stand up to a crow or a gull that comes too near. There seems to be insufficient evidence for what is often stated, that the parent peewits will feign lameness in order to divert attention from their offspring. It may be true, however, for the birds are clever. There is general acceptance of the story that they stamp on the earth, and thus induce earthworms to come to the surface. One can believe a good deal of a bird that does that.

But let us end where we began. The peewit's cry sounds plaintive and prayerful to many ears, but if that be the correct musical interpretation from man's " point of view," it is not what the bird means. The peewit is a gay bird, a jovial gallant, a sociable fellow, a keen lover, a proud parent. One doubts if he knows what it is to be either dull or afraid. And his mate is like himself.

THE SKYLARK

We take this familiar skylark as a type of the birds of the grasslands. It is characteristic of many British links and moors, which, even when not particularly beautiful in themselves, are transfigured in spring-time by the abundance of gorse blossom and enlivened by the almost continuous songs of skylarks. The songsters begin as soon as the sun warms the air a little, and they continue till dusk. In summer they stop singing only for two or three hours in the middle of the night. And not only is the lark singing late and early, by night as well as by day, it sings all through the year. We often hear it in January.

What is most impressive in the skylark's song is its vigorous impetuosity and yet its apparent ease. We hear, as Shelley suggested, the outpourings of a full heart, " a flood of rapture," " a rain of melody." The lark has not nearly so much to say as a blackbird or a thrush, but it says it over and over again untiringly. There are, indeed, variations in his theme, but the compass is small. We agree with John Burroughs : " Its type is the grass, where the bird makes its home, abounding, multitudinous, the notes nearly all alike and all in the same key, showering down as thick and fast as drops in a summer shower." The motif is simple, but there is no doubt as to the skylark's ecstasy—with a note of vehemence too. That is what Wordsworth was referring to when he wrote : " There is madness about thee " ; the song is passionate within narrow limits. An interesting point is the imitative incorporation of snatches of song from other birds, as if to relieve the monotony. For

we cannot agree with those—great authorities too—who speak of the *variety* of the lark's song.

We have considerable sympathy with the American in John Burroughs' story, who, with Shelley's poem in his hand, went hunting about in English fields in search of a skylark and reported that he could not discover even one. We do not mean, of course, that poems should be used as aids in "telling the birds from the flowers," but it does not seem outrageous to inquire whether all Shelley's melodious phrases about the bird are apposite. There is more of the real lark, we think, in Meredith's poem :

"He rises and begins to round,
He drops the silver chain of sound
Of many links without a break,
In chirrup, whistle, slur and shake,
All intervolved and spreading wide
Like water-dimples down a tide
Where ripple ripple overcurls
And eddy into eddy whirls;
A press of hurried notes that run
So fleet they scarce are more than one."

The song is characteristically rendered in mid-air, and the bird sometimes soars so high, perhaps a thousand feet up, that it is lost to view. As Shelley says :

"Like a star of heaven
In the broad daylight
Thou art unseen, but yet I hear thy shrill delight."

Perhaps Shakespeare is finest of all in his simplicity :

"Hark, hark, the lark at heaven's gate sings."

It is a very wooden thing to correct the poets on matters of scientific fact, but John Lyly's lines:

"Now at heaven's gate she claps her wings,
The morn not waking till she sings,"

suggest the remark that the singing is usually a prerogative of the females. We know that there are cases of female larks singing, but that is quite exceptional. The skylark's

song is the audible aspect of "love," and is wrapped up with courtship, but it is possible that the basis is broadening, and that the song is coming to be an expression of vigour, good spirits, and general *joie de vivre*. In some cases the rival males sing as they fight, and we have heard them singing in the rain, and on the ground, and on a whin-bush. They are certainly "blithesome and cumberless."

Half of the courtship is song; the other half consists of a sort of play. The male shows off the outermost feathers of the tail, which are almost entirely white; he hovers with quivering wings a few feet above his desired mate; there are many aerial evolutions which do both parties great credit. There is some evidence that a male lark selects an area or "territory" which he holds as his preserve. It may be noted that the sexes are practically identical, and that both are crested. The buffish-brown colour is well suited for concealment against the ground, yet on the links we frequent the sparrow-hawks get many a lark in spite of their inconspicuousness.

The "blithe spirit," "like an unbodied joy," has a very wholesome appetite; and its success in life depends partly on the fact that it can thrive on vegetable as well as on animal food. It eats insects, including some that are injurious, spiders and small worms; but it also utilises many kinds of seeds, the tender leaves of small plants, and the delicate shoots of grass and corn. It levies a slight tax on seedling turnips and young corn, but this is far outweighed by its destruction of many weeds and injurious insects. It is a crime to kill a lark. The bird's hard times are when snow covers the ground, and if the storm lasts they must trek through the air, say to Ireland, or perish.

In April the lark makes a simple nest in a depression on the ground. It is made of grass stems, finer to the interior, and there is sometimes a little hair. The male collects the materials; the female fashions them into the nest. It is she also who does most of the brooding on the three to five greyish or brownish eggs. After a fortnight the young larks are hatched out—blind and sparsely clothed with down; they require much attention for several weeks,

and are fed on insects and small earthworms, both parents sharing in this labour of love. There are usually two broods in the season, and there may be more. The nest is often well hidden among the grass, but we have noticed on the golf links that it is often built in what man would call a very stupid place, right in the fairway or just at the edge of a little path through "the rough." It is said that the female generally avoids alighting on or flying off the nest; in her comings and goings she runs for a short distance along a twisting path in the grass.

Mr. Pycraft, the distinguished ornithologist of the British Museum, has called attention to the bright yellow colour of the interior of the mouth of the young lark—a feature that is common among the Passerine birds or Perchers. But in the lark there are two black spots at the root of the tongue, and there is a triangular one at the tip. He suggests that these, like analogous markings in some other young birds, may be of advantage in enabling the parents to put food into the nestling's mouth without any fumbling or loss of time. The meals occur every quarter of an hour or so, and it is obvious that the less fuss there is about the nest the safer the nestlings will be from birds and beasts of prey. The young birds leave the nest before they can fly.

The lark is a quick runner on the ground; but the meaning of the great elongation of the claw or "spur" of the backward-turned big toe is uncertain. It is actually longer than the rest of the toe, and one would think that it cannot be of great advantage among the grass. The ordinary flight over the ground is strong and swift, seen at its best in the winter. When we come suddenly upon a lark we see the deep crouching of the body which precedes the rapid leap into the air. But it is the soaring that is so particularly admirable. The wings beat up and down with great rapidity, the usual backward component of the stroke being suppressed. The bird begins to sing when a few feet off the ground, and continues as it rises:

> "The blue deep thou wingest,
> And singing still dost soar, and soaring ever singest."

The ascent continues till the bird is a speck in the sky or quite invisible ; but the singing goes on. After drifting about a little, it may be, the bird suddenly begins the descent —a series of drops with outspread wings, often interrupted by brief hovering ; but the singing goes on. When he is a few feet off the ground the songster stops singing, and drops to earth, or darts off horizontally till he is lost in the herbage.

There are many birds that decrease in numbers as agriculture spreads, but it is otherwise with the lark. It is a lover of open places ; it often nests in the growing corn, where it is particularly safe from molestation. We have spoken of its varied menu and its inconspicuousness of colouring—both making for success in life. Then, a pair of larks may have several broods in the season, so that, as Professor Newton calculated, " their produce on the average may be set down as at least quadrupling the original stock." Of course there is stern sifting by man and severe weather, by stoats and weasels, cats and rats, hawks and crows, but larks work with a large margin, and they are more than holding their own. Long may this continue ! In a general way the lark may be called a resident bird in Britain, but it is more accurately termed a " partial migrant." There is a great deal of coming and going, and the migration phenomena exhibited by larks are of unusual intricacy. One of the striking facts is the autumnal arrival of enormous flocks from the Continent, the stream sometimes continuing for several days. But we have perhaps said enough to indicate the general Natural History of a universal favourite.

THE CURLEW

A very attractive bird to follow through the year is the curlew. All through the long winter in the North there are great flocks of curlew about the low-ground fields and along the shore. Often we have counted fifty together—a merry throng, though their cry is plaintive—" Cur-lee, cur-lew, cur-lee." It is in the wet sand and in the shallow pools that they probe so successfully for all manner of small shore animals. The curved bill is about six inches long,

and very sensitive at the tip, as is usual among wading birds, for the food is felt rather than seen.

When there is much snow on the hills and on the moorland the curlews in the North of Scotland do not leave the shore till the beginning of April. They hurry away when the weather changes for the better, and with their courting calls they make glad the lonely places of the hills. Of the summer calling, Burns said: "I never hear the loud, solitary whistle of the curlew in a summer noon . . . without feeling an elevation of soul like the enthusiasm of devotion or poetry." But what we hear in spring is not the sober summer call; it is exuberant and joyous; it has a beautiful trill; it is a rippling song. The male bird climbs high in the air and poises like a hawk; he sinks and rises, he circles and hovers again, and through all the aerial evolutions he hardly ceases to cry "Courlie, courlie, courlie."

The nest is simply a depression in the ground, with a lining of dead grass; and there are four large olive-brown or greenish eggs with cinnamon spots. There are often several false "nests," which may distract the enemy's eye. Possibly, however, they only mean that the birds began to sit and then saw a place they liked better.

The parents are quite alike, except that the hen-bird is slightly larger; both brood, and they often sit very close, their variegated brown plumage being well suited for concealment among the heather or withered herbage. When danger draws very near the nest, the bird slips off and runs a bit, or, if that is not practicable, takes wing at once. When the fluffy grey-buff young ones hatch out, the parental care becomes even more intense. As we approach, we may hear the slightly sibilant danger-note, and the male rises, making the moorland ring with his protestations. They say curlews have about ten words altogether. When we pass out of sight the alarm-cries cease, and the male settles down beside his mate with "a musical utterance of satisfaction, a long gurgling and quavering note, exceedingly wild."

People sometimes ask how anything like the proportionate length of the curlew's bill can be accommodated inside the egg during the month of development, and the answer is



Photo : Jos. A. Speed.

CURLEW ON THE ALERT.

The Common Curlew (*Numenius arquata*) belongs to the same family as the snipe and sand-piper, and, like these birds, possesses a bill long enough to reach the small creatures on which it feeds in boggy ground. All summer it lives on the moor; but in winter frequents the sea-shore. "Cur-lee, cur-lee," is the plaintive cry to which it owes its name.

biologically interesting. The young curlew has a short, straight bill, like a plover's. Here is a hereditary character which does not find expression for some weeks after the chick has stepped out into the world. The young curlews are charming; their mottled brown suit hides them; they have the instinct to scatter and squat when the danger-note is sounded.

The birds spend the summer on the moorland, searching for insects and worms, snails and slugs, with berries as dessert. But as the food becomes scarce and the daylight short, the birds begin to congregate in flocks. For they are as gregarious in winter as they are solitary in summer. In August we see the V-shaped flying phalanx making for the shore. The flight is very rapid, for the wings are long and the breast-muscles powerful, but as the birds come near we can see the trailing, slate-grey legs and the long decurved bill against the sky. We know that another summer is over as we hear them cry "Gur-lech, gur-lech."

Compared with the Virginian Plover's flight from Labrador to Brazil, or the Pacific Golden Plover's flight from Alaska to Hawaii, across the waste of seas, how small the curlew's migration seems—from the moorland to the shore. Yet it is in principle the same seasonal mass-movement from a breeding- and nesting-place to a feeding- and resting-place. Be the journey long or short, birds always breed in the colder part of their migratory range. Moreover, although some of the British curlews have a very short migratory journey, there is often an autumnal influx of large flocks which reach our shores from the more northern parts of the Continent.

The curlew's first cousin, the whimbrel, is chiefly a bird of passage in Britain, breeding farther north, and wintering farther south. It is about ten inches shorter than the curlew (which is about twenty-six inches long), and it is less of a shore-bird. To its rippling whistle, often seven times repeated, it owes its name, "Seven Whistler," and another name, "Titterel," is also suggestive. Dr. Masefield writes:

> "And like the shaking of a timbrel
> Cackles the laughter of the whimbrel."



Photo: T. M. Blackman.

YOUNG CURLEW, THREE OR FOUR DAYS OLD.

Like the chicks of the domestic fowl, the young Curlew can run and peck as soon as it is out of the egg, and at three days old, the age here represented, it is already a quick traveller and very independent. It well deserves to be called "precocious."

Burns and Robert Louis Stevenson and many others have expressed their love for the curlew, and who will not join in the tribute? The plumage is beautiful, and so are the hazel-brown eyes; the long bill seems to balance the long legs; the flight is perfection, and the birds can swim as

well as run. They are courageous creatures, not hesitating to attack intruding birds of prey; they "feign injury" when driven off their eggs; they have a good vocabulary. In every way they are admirable and attractive.

THE OYSTER-CATCHER

In illustration of the quest for food let us take the case of the Oyster-catcher, a common resident bird in Britain, with its counterpart in America. It is an attractive bird which every one can recognise at a glance, for it has conspicuous black and white plumage (hence its name Sea-Pie), an orange-vermilion beak, and bright flesh-coloured legs. It flies at a breakneck speed, crying very loudly "quick, quick," or "huick, huick." It is a bird of the shore, but when spring comes many of them go up the northern rivers in a merry throng. They fly high and low, always as if they were in a great hurry, but they are simply playing themselves. As April passes, the crowd splits up into pairs, though often one sees them flying in threes—a female and two males. They are courting, and the female bird is long in making up her mind which of her suitors she likes best. The male runs along the sandy bank and pipes to her, getting a trill into his simple "song"—"kerree, kerree." He bows and sways from side to side, and his neighbour comes and does the same. The rivals frequently rush at one another. But all they say and do is often love's labour lost, for the female seems to get bored and walks away.

After a while, however, they pair, and make a very rough-and-ready nest—little more than a few pebbles and shells and pieces of drift. This apology for a nest is made in a sandy nook among the rocks on the seashore, or among the dunes, or on the shingle by the stream. A favourite place is on a little river-island. The eggs, usually three, are much less conspicuous than one would expect, for they have dark spots and blotches on a yellowish ground colour. Both parents share in the brooding, and the male often watches while his mate sits. If an intruder appears, the male sounds the danger-signal and the female slips quietly off the nest.



Photo: T. M. Blackman.

OYSTER-CATCHER ON ITS APOLOGY FOR A NEST.

When oyster-catchers are running about they are very conspicuous birds, and still more so when flying. They advertise themselves with their ringing cry, "*feet, feet.*" When resting, in a normal environment, they are much less conspicuous: but an interesting feature is the new courage that the nesting bird shows in its aggressive resentment of intrusive enemies, including man.

She runs along the ground for some distance, and then the two of them take up a position from which they can see what happens. They are anything but timid birds, and will defy enemies much larger and stronger than themselves.

The nestlings are well hidden by their grey and black down, and they squat when they hear the parents' danger call. They would readily escape notice if they remained quiet, but they are not so patient as some other young birds, and they are apt to betray themselves by getting up and trying to run before the danger is past. They grow quickly, however, and are able to fend for themselves in about three weeks.

At the end of summer the oyster-catchers that have made many a river merry, rejoin their kindred who remained near the seashore. The river-birds feed mostly on small water animals, such as insect-larvæ and water-snails, which they find under stones and among water-weed; and they are often to be seen on the farmer's fields, probably on the search for earthworms. It may be mentioned that the turnstone, a sort of second cousin of the oyster-catcher, is in the habit of tipping over flat stones and bunches of seaweed for the sake of the sand-hoppers, worms, and other small fry which it finds underneath. One of the chief lessons to be learned from a study of the quest of food is that *in many cases* each kind of creature has its own ways. What are the oyster-catcher's ways?

We wonder why the bird was called oyster-catcher, for has any one ever seen it catch an oyster? It is a past-master, however, in dealing with mussels, which form a considerable part of its food in places where they are abundant. It has at least three ways of tackling mussels. First, it waits for the proper state of the tide, when the mussel beds are covered with shallow water suitable for wading in. For when water covers them the mussels allow the valves of the shell to gape; they are feeding on inswept microscopic organisms. The oyster-catcher, wading quietly, sees a gaping shell, and instantly its strong bill is in and the business is half over. It cuts at the muscles that keep the valves shut; the shell opens up; the palatable flesh is spooned out, and then the oyster-catcher uses its bill like a

pair of scissors and shears off any pieces of muscle and skin that have been left adhering to the inside of the shell valves. The bird works with great quickness, for if the tide is coming in, the water above the mussels will soon be too deep for even a long-legged water-wader, and if the tide is going out the mussels will soon be exposed to the air and will close their shells tightly.

But the oyster-catcher is by no means baffled by closed shells. It is able to give blows so shrewdly that it opens the shell, often with very little breakage. The most interesting point is that the oyster-catcher alters its mode of procedure according to the way in which the mussel is lying. For all mussels are not fixed to the rocks in precisely the same position. It is in these little adjustments that we get glimpses of controlling intelligence.

The third way of dealing with mussels is to swallow them outright, but this is possible only when they are comparatively small. This is the method that the oyster-catcher also uses in dealing with periwinkles—the poor man's oyster—with small crabs, with worms, and many other shore animals.

Its way of treating limpets is peculiarly interesting. Every one who has visited the seashore knows that these molluscs, with their conical shell and adhesive "foot," cannot be *forced* off the rock. If you try to do this, you are more likely to break the shell or your walking-stick. The only way is to take the limpet by surprise, and give a quick, firm knock, which sends the shell flying. Now the oyster-catcher does one of two things. It watches for a limpet on the prowl, for they make little journeys in search of seaweed, and when they are on the move the "foot" is gliding, and the margin of the shell is raised a little off the rock. That is the oyster-catcher's opportunity. In goes its bill and off comes the limpet. The bill is strong enough to be used as a lever.

The oyster-catcher's second method of dealing with limpets is less frequent, but it is not less effective. The bird, moving quietly, suddenly gives the limpet a sharp sideways stroke, delivered with great velocity, and just at the proper place. This dislodges the limpet, and the rest is easy.

The oyster-catcher often carries its limpet to a particular spot and there scoops it out of the shell. Great numbers of empty limpet-shells are sometimes found lying together on the shore, and these testify to the oyster-catcher's hearty meals. They correspond to the " kitchen middens " of prehistoric man—great banks of shells, the tell-tale evidences of many a feast. But our point was simply to take a common bird—as the oyster-catcher is—and discuss its varied quest for food.

SWANS

When we see swans swimming with half-raised wings, sinuously curving neck, and erected tail, swimming swiftly with powerful strokes of their black feet, and yet with superb unhasting dignity, we cannot but be thrilled with the magnificence of life. The swan is a poem, a picture, a harmony, and a high-bred aristocrat besides. In plain prose, the swan is one of the most attractive of birds, and in daily life it insists on our respect. For though it may not be able to break our leg or arm, as is so often said, it can make us feel and look very small. It can certainly break a rib and kill a dog.

We should like to believe the tradition that Richard Cœur-de-Lion brought the swan to Britain. It is just the sort of thing he would do, for the swan is fearless and romantic. Our swan is a wild bird (*Cygnus olor*) in some parts of Europe ; but most of those seen in Britain in places beyond man's patronage are " escapes " that have become feral. It matters little, however, for domestication has left almost no mark on the Mute Swan. Perhaps it would be more correct to say that the swan has condescended to accept man's protection than to call it domesticated. In old days man's patronage was more marked, for it used to be customary to carve a design on the swan's bill and to pluck the pinions once a year. In places like the Norfolk Broads pinioning has been in great part given up, and the reward of this has been the sight of great flocks of swans on the wing. The approach of the glancing wings and the splash when a dozen birds alight on the water is pictured by Miss E. L. Turner in her fine book on *Broadland Birds*.

"Away over the marshes one catches a glimpse of what appears to be a line of milky white foam drifting over the reed-beds. Soon this takes shape as the swans advance, and if one's ears are quick to hear, the noise of their rhythmic wing-beats may be heard a mile away—a clear, distinct sound, like the hum of a musical humming top." Mr. Coward compares the throbbing sound to the noise of horses galloping on hard ground. Unlike the Whooper Swan, which utters a loud, metallic, barking note as it flies, the Mute Swan saves its breath when it is on the wing. If it has a flight-call, as some authorities maintain, it does not often make it heard.

We hasten to add that the Mute Swan is far from being mute. Its daily life is not without conversation. There is an angry and ill-smelling hiss when the bird is provoked; there is a sort of churring growl that signifies protest and disapprobation; and, thirdly, there is what Yarrell called a "soft, low voice," rather plaintive and pleasing. But our swan would not have been called mute if it were not a *relatively* silent bird, and we may notice in this connection that there is very little profit in scientific criticism of the poets. "Swans sing before they die; 'twere no bad thing should certain persons die before they sing"; to criticise such neatness is folly. We would not criticise it for the world, and we do not like Michelet's suggestion that swans used to sing in Virgil's day in the sunny South, but lost their voice when they came to live in the sterner North. This is unusually matter-of-fact for Michelet, and it seems to assume the transmission of acquired characters, in which we do not believe.

There is something attractive in the old conceit of the swan's breaking its vow of silence in the twilight of its life. What can be the explanation of such a daring fancy?

"The Silver Swan, who living had no note,
When death approached unlocked her silent throat;
Leaning her breast against the reedy shore
Thus sung her first and last, and sung no more;
'Farewell, all joys. O Death, come close mine eyes,
More geese than swans now live, more fools than wise.'"

As a matter of fact, a Pen or Cob swan is too much of a lady or gentleman to make such a stinging farewell as these lines suggest ; but how did the swan-song idea get so strong a grip ? Mr. Hamerton suggests that the perfection of the swan prompted man to give a touch of uniqueness to its death. " Since the bird who could match the eagle in courage and man himself in longevity, and with whose beauty the king of the gods did not disdain to clothe himself, had never given the least sign of any musical talent or accomplishment ; the fertile human imagination, always so unwilling to leave any hiatus in its ideals, invented that most poetical fable of the swan's song at the close of a songless life."

This is ingenious—almost as ingenious as the theory of the Queen of Navarre, who suggested that the bird's spirit, leaving the body through so long a neck, would produce musical murmurs ! Perhaps, however, the Queen of Navarre was on the right tack, not exactly in explaining the swan's song, but rather its absence. For we believe that the reason for the Mute Swan's muteness, as compared with the vociferousness of the Whooper Swan or Bewick's Swan, is to be found in the fact that *it sings with its neck*, which is much more mobile than in the wild species.

What we mean may be illustrated by one of Miss Turner's delightful stories. Swans, it may be noted, are monogamous and very affectionate. The mother or Pen can hardly be induced to leave the young ones ; and the father or Cob, though he often goes off for a little by himself, is devotedly solicitous and passionately fearless in defending his mate and offspring if there is any danger. On one occasion, when the Cob was in charge, the Pen did not return to the nest when she was expected. As hour after hour passed, the Cob became more and more uneasy and anxious, " continually rearing himself up and trumpeting." He paid no attention to Miss Turner's coaxing (they were old friends), and he refused to have any bread. After some hours Miss Turner set out in a canoe to search among the reed-beds, and suddenly met the Pen hurrying along, head in air, hissing and scolding. " Hearing her mate call she

responded, and I followed to see what happened. The Cob left the cygnets on the island and advanced to meet the Pen at a great pace. When they met much affection was shown on both sides. They rubbed bills, intertwined their long necks, and chortled with joy, then swam home side by side, and were greeted by the cygnets with shrill pipings." The cause of the Pen's belatedness is not essential to the story (she had an ugly cut on her bill, and had probably been having " words " with another proud Pen about the respective merits of their cygnets) ; our point is that the movements of the neck, which are very marked in the courtship, take the place of song, though not, of course, of speech.

The Mute Swan, with which every one is familiar, is easily distinguished from the two wild species in Britain, the Whooper and Bewick's, both winter visitors to Scotland. For the Common or Mute Swan has a black knob and patch at the base of an orange bill, whereas in the two others the pattern is reversed, the bill being yellowish at the base and black towards the tip. The wild species have a stiffer neck, and they do not show that charming custom of swimming with the wings half raised into a fascinating basket. It is worth looking at the breastbone of a wild swan to see how the windpipe descends right into the keel and makes a complete turn on itself. This is not seen in the Mute Swan.

The swan is a good lover and a good hater. As one would expect from its great beauty, it is very stable and long-lived ; it has attained to harmony, and does not wilt or "sport." It is a very intelligent bird, as may be inferred even from such simple things as raising the nest if the water rises, and making a little gangway for the cygnets. Swans are model parents, as shown, for instance, in not allowing their cygnets to get to bed (though they sometimes go to sleep) before every feather is dry. To carry their family on their back is pretty, but to hold out a foot as a jumping-up step is genius. Finally, though we are not nearly done, swans are vegetarians. In fact, swans are almost perfect except when they are walking on ice ! Then they are geese.

When swans get their way they build a large nest of water-plants, which may be two feet high and even six feet

in diameter. Its height can be added to if the water rises. In the middle of the big erection there is what might almost be called the inner nest, which is lined with down. Here are laid, usually in April, the five to twelve greenish-white eggs, about 4·3 by 2·9 inches. The Cob shares brooding with the Pen and the time required is between five and six weeks. As already stated, the swans mate for life, and the male is a devoted father. If the nest is threatened he becomes very fierce, " busking," as it is called. This is well described by Mr. T. A. Coward in his delightful book, *The Birds of the British Isles*, one of the best illustrated and most convenient of bird books. " In this terrifying performance the wings and scapulars (shoulder-blade feathers) are further raised, and the neck is drawn back until almost hidden by the wings ; the bird forces itself forward in rushes with simultaneous strokes of its feet, ploughing up the water." The Cob is not only very courageous, he sometimes insists on taking more than his share of the brooding, a duty that spells patience.

The young when hatched are clothed in sooty-grey down, which is succeeded by dark sooty-brown feathers. These again are gradually replaced by white, but the change is not complete till the birds are over a year old. In rare cases, it seems, the cygnets are white from the first.

The Whooper Swan and the smaller Bewick's Swan have their representatives in North America, in both cases larger that the European forms. One of the two is called the Trumpeter, *Cygnus buccinator*, and has an expanse of wing of seven feet ten inches. It is said to be a somewhat truculent, quarrelsome bird, but in spite of this it is becoming very scarce. Its voice is compared to a short blast on a French horn. The other is the Whistling Swan, *Cygnus columbianus*, still found in some abundance ; it has a yellowish patch, deepening almost into scarlet, on the bill, whereas the Trumpeter's bill is altogether black. Mr. D. G. Elliot describes the " swan song " of a stricken Whistler : " most plaintive in character and musical in tone, it sounded at times like the soft running of the notes in an octave."

In South America there is a small swan, called Cascaroba,

but some authorities insist that it is a goose. It has black tips to the longest feathers of the wing, and reddish bill and feet. "It feeds on land, has a loud trumpeting cry, and a less noisy flight than the true swans." True enough, however, is the other South American swan, the black-necked swan, *Cygnus melanocoryphus*, which is black on the head and for most of the neck. In Southern Australia and Tasmania there is a handsome black or brownish-black swan, now becoming scarce. Its dark colour is relieved by snow-white pinions; "the coral-like bill is banded with ivory"; some of the feathers, such as those along the shoulder-blade, are beautifully curled. The divergence of Australia from other countries was emphasised by the discovery of this black swan (in 1697), and the bird was adopted as the armorial symbol of Western Australia. It is sometimes domesticated in England, and never fails to win admiration for its intrinsic beauty as well as for its curious contrariety.

It will be seen, then, that there is considerable variety among swans, though there are not many different kinds altogether.

They form a compact, well-defined sub-family in the family Anatidæ, and they are not distantly related to geese, which form another sub-family. The privilege of keeping swans used to be restricted in Britain to the larger free-holders, but it was gradually extended. Prof. Newton tells us in his *Dictionary of Birds*, that "in the reign of Elizabeth upwards of 900 distinct Swan-marks, being those of private persons or corporations, were recognised by the royal Swanherd, whose jurisdiction extended over the whole kingdom." It used to be a big business to visit the important flocks in July or August each year, and put distinctive marks on the young birds. Professor Newton, writing in 1896, says: "The largest Swannery in England, indeed the only one worthy of the name, is that belonging to Lord Ilchester, on the water called the Fleet, lying inside the Chesil Bank on the coast of Dorset, where from 700 to double that number of birds may be kept—a stock doubtless too great for the area, but very small when compared with the numbers that used to be retained on various rivers in the

country." Swans are not on the increase, but one wishes that all beautiful birds were as safe.

THE BITTERN OF THE MARSHES

One of our rarest winter visitors is the bittern, which we welcome not only for its beauty and interest but as a bird that belongs to Great Britain. For it used to be a common breeding bird in England and Southern Scotland, and there can be no doubt that when Neolithic man—a "long-headed, square-jawed, short but agile-limbed hunter and fisherman"—began exploring North Britain some ten thousand years ago, one of the most frequent striking sounds he heard was the bittern "booming from the mire." But slow changes of level, such as the "fifty-foot beach" indicates, reduced the extent of the swamps where the bittern was at home. As draining and reclaiming increased the bittern decreased. Moreover, the bird afforded good sport, and was more or less edible. Last, and worst of all, came the collector, and the bittern said good-bye as a breeding bird about the end of the 'sixties. In 1911, however, came the good news that Miss E. L. Turner and Mr. James Vincent had found a bittern's nest on the Norfolk Broads, and now the bird is coming back again, if people would only leave it alone. In 1918 Miss Turner knew of seven nests within four square miles, and in 1923 there were eleven. "The deep, resonant challenge of bittern calling to bittern across the great wide silence of the misty marshes heralding the gorgeous pageant of a Broadland dawn is now a familiar sound in many areas." This is most encouraging news, and we hope the bird will never haye to say good-bye again. Extermination of a beautiful creature means dullness of outlook, but preservation follows when men awaken to the value of their entail. Therefore we venture on an appreciation of the bittern, owing much of course to Miss Turner's *Broadland Birds*—a collection of fascinating studies of high scientific and artistic merit.

The bittern is one of the herons, a large bird, about two feet long, with a wing-length of about a foot. It is a study

in brown, showing much golden buff, many black markings, and a white throat. The legs and feet are bluish green. Males and females are equally handsome and equally inconspicuous. For the main significance of the colouring is that it gives the bird a cloak of invisibility. When the bittern stands stock-still among the reeds, with the tip of its bill pointing up to the sky, it has become a part of the scenery of the Broadlands. As Mr. Pycraft says: "Long lines of dark chestnut-brown running down the front of the neck simulate the shadows between the reeds, the lighter background and thick dark lines simulate dead reed stems." The bird melts into its surroundings. As in the American Bittern and the Little Bittern there is a remarkable peculiarity in the absence of ordinary contour feathers on the back of the neck, which bears only loose downy feathers. But this region is partly shielded by an erectile fringe of long feathers, which extend along each side of the neck and meet on the back of the head. As in herons, there are some patches of "powder-down" feathers whose tips break off into minute platelets of horn-dust, believed to be of some use in plumage-dressing. The "powder" feels greasy between our finger and thumb, but that seems to be a mechanical illusion. It is quite dry, not oily. Even more of a puzzle is the "pectination" or comb-like appearance of the middle toe; but this occurs in many birds.

When the bittern is discovered, in spite of its self-concealing coloration, it abandons the erect posture and crouches, with its head drawn down on its shoulders, or with the neck outstretched horizontally. It broadens out its frills and raises its crest, and must be carefully watched. For it can suddenly shoot up to its full height and drive home its sharp beak with great rapidity and precision. It may strike its assailant in the eye. A bittern is reluctant to take wing and flies somewhat heavily, with owl-like silence, with wing strokes more frequent than a heron's. It can run with great rapidity, threading its way amidst the miniature jungle of the swamp.

One cannot help being a little sorry that the booming bittern does *not* thrust its bill into a reed, not even into the

water or the mire. It booms with its bill pointing up to the sky, and it is the male who booms. Mr. Coward speaks of the call as " a deep, bovine, resonant note, certainly audible for over a mile. I have heard it all day and all night in May, and listened to three or more birds answering one another. The boom is repeated three or four times in succession, with a one or two second interval between each note, then a pause of variable duration."

The word " bovine " for the boom is interesting, for it suggests the bittern's technical title Botaurus, the French name Taureau d'étang, and other designations referring to ox-like or supposed ox-like bellowing. Miss Turner tells of an acquaintance who refused to pass a certain corner of the Broad at night, because of a " gurt big bull a-bellowing on the maash " ; but she says that the bittern's boom is not nearly so raucous as a bull's bellowing. She has heard it from a distance of three miles, and no lover of birds can help envying her an experience of a May night in the full moon, when " red-shanks were yodelling, snipe bleating, lapwings calling, reed—and sedge—warblers singing as if their hearts would burst." " Beneath this riot of song and accompanying it like a deep bassoon was the booming of six bitterns challenging each other across the wide marshes." The male begins to boom early in February and ceases in mid-June. There can be no doubt that the boom is a call to the female, who sometimes answers back with a subdued but exciting " wumph." But the boom is also a challenge to other males, who answer back bravely. Corresponding to these two aspects of the booming are the male bittern's aerial displays and occasional aerial combats. To be distinguished from the booming are the raucous " aark " " aark " call-notes of both sexes ; and very different also is the young bird's " bubbling " call for parental help, " which can be easily imitated by blowing through a straw into a glass of water."

The nest is a simple structure—a bed of dead reeds among the living reeds ; and the female sits for about three weeks on the three to six olive-brown eggs. The young birds are strong and active in two or three days after hatching

and pugnacious from the first. They show a remarkable primitiveness in using their " hands " in moving across the nest or in supporting themselves when standing up. They require to be fed every hour from dawn to dusk, and the mother is kept very busy hunting for eels and other fishes. Miss Turner gives a lively description of the young bittern, standing about six inches high when four or five days old, with long, soft, wavy, tan-coloured down blowing over its face, with an elusive blue bloom on the bare patches of its skin, crouching and straightening, throwing itself on its back and kicking, thrusting aggressively with its bill, " more like an animated golliwog than anything else." " After the first week it is very difficult to round up the young. At the slightest approach of danger they walk off and hide in the reeds, where their soft brown and blue-green colouring harmonises completely with the dull brown sheaths of the reeds, and with the young reeds themselves." They can efface themselves without moving, and that is well, for they make a loud clamour when they are being fed, and they cannot fly till they are quite ten weeks old. Bitterns feed on small animals of the marshes, such as water-voles, frogs, newts, and fishes, and they do no harm. They may have some natural enemies, such as the marsh-harrier, but their wide geographical range from Ireland to Japan and throughout swamp-lands in Africa shows that they are securely established as long as their characteristic haunts remain. Which is our hope and prayer. Long may the bittern boom !

THE DABCHICK

It is certainly a great privilege to live near a river where one can see dabchicks, or Little Grebes, disporting themselves. Not that one can see them whenever one likes, but they are oftener to be seen than a casual visitor would think. They are dainty, compact little birds, about nine inches long, with almost no tail. Their colouring makes for inconspicuousness, dark brown above, greyish white below, and a little paler on the whole when winter comes. There is an intense pleasure in watching dabchicks, their

movements are so vivacious. They are artists in self-effacement, for not only are they continually turning somersaults and diving, but they have got some other way of *simply disappearing*. How this vanishing trick is done we do not know. And even the diving movements are so quick that the eye can hardly be sure—even after a hundred observations—of what actually happens. The bird raises its body vertically out of the water, turns a somersault, and goes down head foremost; but our words are too terribly clumsy for the marvellous gymnastic feat. Under water, dabchicks swim deftly with their "chestnut-leaf" feet, the lower leg showing a remarkable swivel-like adjustment; but Macgillivray may be trusted in his observation that they also use their wings. Like some other aquatic birds they fly in the water. Every one knows that the dabchicks often reappear very quickly a long way from where they disappeared, so the locomotion under water must have a great speed. If this grebelet uses wings and feet at once it is almost like becoming a quadruped again, for the ancestors of birds were reptilian quadrupeds.

Dabchicks frequent lochs and ponds and the slow-flowing reaches of rivers, and they are found from the high moorland to the shore. In the winter, when the lochs may be partly frozen, and when small water animals are scarce, they often come to an estuary, which they enliven with their pretty ways, or they may frequent the lagoons of a seashore marsh. Except in so far as a few come to Britain in winter from further north, and in so far as many of them move from one part of the country to another, dabchicks may be called resident birds in this country. They do not readily take to wing, but when they do, they fly at a great speed and very straight. It is rather a surprise to find that they can also run quickly if hard pressed.

The food of the Little Grebe consists of aquatic insect-larvæ, water snails, little fishes, and a salad of weeds. It is the comparative minuteness of the items on the bill of fare that makes the incessant diving necessary. For many birds it is a case of "many a pickle making a mickle."

Little is known in regard to the courtship of the dabchick,

which is a pity if it even approaches that of the Great Crested Grebe, so carefully studied by Professor Julian Huxley. The mating birds call to one another cheerfully, saying whit, whit; and they work together in building a rather large nest. This may float, attached to rushes, or it may be firmly moored to a branch that has fallen into the loch, or it may be built up from the bottom in shallow water. In any case, the nest is constructed with a large margin of safety, so that the saucer-like hollow in the middle is always well above the surface of the water. It is adjusted so that the water does not reach the eggs, or the brooding bird, or the nestlings. That would be fatal.

The nest is made of water-plants, and as they die they ferment, thus raising the temperature—all the better for the development of the eggs. The warmth of the decomposing plants makes it easier for the brooding bird to take an occasional holiday, and, as a matter of fact, the two parents may be seen gaily playing together while the eggs are being incubated in the warmth induced by the activity of Bacteria! For there is no rotting without Bacteria. When the precious nest is thus left to itself, a blanket of weeds is very rapidly drawn over the four to six white eggs. Both parents build and both parents brood; and there are two clutches in the year, between April and August. The eggs, like those of other grebes, are biconical, the two ends being almost or quite alike. They have a chalky shell, and this gets stained by the damp weeds on which they rest, so that after the first week or so the clutch of eggs becomes almost invisible.

The nestlings are attractive little creatures with black down changing gradually to brown, and reddish harlequin-like or agate-like stripes changing gradually to white. The young ones are fed by both parents, and their education begins early. The mother or the father takes them for a little voyage, and they hold on to their parent's back. When the parent bird submerges its body the youngsters have perforce to swim. If there is some danger, the mother keeps the young ones under her wings, and may dive with them in that position. We read that when they are resting

on the nest under their mother's wings they poke out their heads in a winsome way when the father approaches with food in his mouth. We hope to see this some day. When the young dabchicks have found expression for their diving and swimming instincts, and when they have learned some lessons about food and enemies, they may still be seen swimming about with their parents. But some day there is a big alarm, the family party breaks up and the youngsters scatter, never to come together again.

When we ask how this attractive bird, which Ruskin called " our little living ripple-line of the pools," holds its own to-day, we find the answer first of all in its minute size. It is one of the " little people," easily overlooked. Its coloration also makes for self-effacement. Moreover, it is a singularly quiet bird ; for, as Professor Newton points out, " it often happens that a pair will frequent a small weedy pond, nigh unto a human habitation, and rear their young there, without their existence being detected, though they stay for the whole of a summer." And again, there must be safety in their extraordinary alertness ; it is almost impossible to take a dabchick by surprise. But a bird may be alert and yet not quick to move, as is plain in the case of geese. So to alertness the dabchick has added quickness of reaction. They disappear " like a shot," fortunately often quicker than the shot. The reappearance somewhere else is also a good life-preserving trick. We are not forgetting that the dabchick has a fairly large family and that the youngsters are well educated, getting a good send-off in life, but in the main the bird survives because of its alert elusiveness and its rapidity of action. Ruskin talks a good deal of nonsense, we think, in his account of the dabchick in *Love's Meinie*, but he was perhaps right in calling it " the prettiest bird, next to the kingfisher, that haunts our English rivers."

HUMMERS

Humming-Birds are especially, though not exclusively, flower-visitors, and they are themselves like flying flowers.

No doubt some are mountain-birds and may ascend the Andes, for instance, to near the level of perpetual snow, but most of them are linked to flowers and therefore to summer.

It is difficult to avoid extravagance in writing about humming-birds. The colours are so brilliantly beautiful that Audubon called the humming-bird a "glittering fragment of the rainbow," and Buffon wrote that "the emerald, the ruby, and the topaz glitter in its garb." The movements are so graceful and aerial, as it hovers with humming wings, or flits from flower to flower like a butterfly. Not only "living gems," as Gould, their monographer, called them, but "dancing gems." Then there is the large number of different kinds—at least five hundred species—a fact that spells success. And the number of individuals is also, in many cases, enormous, just as if they were insects! Another attraction is in their dainty feeding, for, as one of the earliest observers wrote in 1671 of the Ruby-throated: "'Tis an exceeding little bird, and only seen in summer, and mostly in gardens, flying from flower to flower, sucking honey out of the flowers, as a bee doth; as it flieth, not lighting on the flower, but hovering over it, sucking with long bill a sweet substance." As a matter of fact, humming-birds feed on insects as well as on honey, and in some cases they are mainly insectivorous. But they always feed daintily.

There is a fascination, too, in their minuteness, for the total length of the smallest is two and a quarter inches, its body being less than the bulk of the head of the largest, the Giant Hummer of the Andes, which equals a good-sized swift. As one looks at a dwarf humming-bird, one cannot help wondering if it really contains the counterparts of all the organs in our body. The Vervian Humming-Bird of Jamaica is about two and a half inches in total length; its nest is three-quarters of an inch in diameter; the eggs are 0·28 of an inch in length, and 0·20 of an inch in width. Here is a case of *maxime miranda in minimis!*

Humming-birds are confined to the New World, where they extend from Patagonia to sixty-one degrees North

Latitude in Alaska. They are most successful in mountainous countries, and their centre of distribution is among the Northern Andes. There is a peculiar group of Hermit Hummers, which are characteristic of Brazil. Of these, Dr. Robert Ridgway writes in his masterly memoir on humming-birds : " They are all very plainly coloured birds, with little metallic colouring, sometimes none, and instead of living in the sunshine and feeding among the flowers, they inhabit the gloomy forests and subsist wholly on insects gleaned from the branches and leaves of trees."

In Temperate countries, humming-birds are migratory. Thus, the Ruby-throated has its summer home in eastern North America, while in winter it goes as far south as the Isthmus of Panama. It, and some others, may have a migratory range of over two thousand miles. Dr. Ridgway notes that : " It is only in the warm valleys of California and in Southern Florida that any species of humming-bird regularly passes the winter within the borders of the United States." He also calls attention to their remarkable *vertical* range : thus, he saw one in the doorway of a ranch in Ruby Valley, Nevada, at an altitude of 6000–7000 feet, and another of the same kind on the same day, nearly 6000 feet higher on the summit of the East Humboldt mountains.

An ordinary bird in everyday flight rows on the air with its wings, but a humming-bird has, as it were, revived the insect's method of flight—by extremely rapid vibrations of the wings. This is associated with the unique structure of the wing, for the upper-arm and fore-arm bones are relatively very short, the primary pinions (ten in number) are relatively very long, and supported on long hand-bones, whereas the secondary pinions (six in number) are much abbreviated. But these secondaries, borne by the fore-arm, count for most in the flight of ordinary birds. Thus the humming-bird has come to be a very rapid *flutterer*. It flits from flower to flower ; it hovers with its body almost vertical while it thrusts its tongue into a blossom ; it buzzes like a bee among the flowers near the ground ; it suddenly shoots up in the air and over a tree-top. But there is no vigorous striking of the air, as in ordinary birds ; what is seen is an

extremely rapid vibration. In proportion to the humming-bird's size the muscles of flight are magnificently developed, and the keel of the breastbone to which they are attached is, size for size, stronger than an eagle's.

The rate of a humming-bird's flight is probably less than it seems ; what is remarkable is the number of wing-strokes per minute. Dr. Lucas estimates the number at about 500, whereas the gannet, or solan goose, a bird with slow strokes, but not of slow flight, has about 150 per minute. Five hundred strokes of the wings in one minute must imply a prodigious expenditure of energy, and it is not surprising to find that the humming-bird has a very strong heart. It is not for nothing that humming-birds are related to swifts ! Their flight lacks momentum, and they may be caught by a cobweb ! They cannot run on the ground ; they keep to trees and to the air.

The bill of the humming-bird is usually slender and elongated. In one case it is four and a half inches long, exceeding the length of the whole bird. In most species it is almost straight, but in some it is bent downwards, and in the Avocet humming-bird it is bent upwards—these strange twists being apparently suited for dealing with flowers with curved corollas. The lower jaw fits into a groove in the upper jaw, so that the closed bill is like a tube. Corresponding to the typical bill is the extremely long tongue, which can be whipped out and in with great rapidity. It is tubular at its base, but divides, at about half its length, into two free tips. Each of these is a sort of half-tube or gutter, and also bears an up-curled membranous fringe somewhat frayed towards the end. The whole apparatus seems to be suited both for nectar-sipping and for entangling small insects that frequent the flowers. In certain cases the hummers are of real use to the flowers they visit, for some carry the fertilising golden dust or pollen from blossom to blossom, and there are others that destroy unwelcome floral visitors.

Humming-birds are very successful in the struggle for existence, and this is shown in certain features of their behaviour. They are very inquisitive, and they often fly close to the observer's face as if to take a good look at him.

They show a " charming confidence in the human species," and may be readily taught to come for honey. The males are very pugnacious—big souls in little bodies—and they not only fight with their kin at the breeding season, they drive off much larger birds that intrude into the vicinity of the nest. There is a good deal of twittering conversation among humming-birds—expressing fondness, good-humour, anger, and alarm, but " it is doubtful if any approach more nearly to song than a sort of warbling twitter, which the males of many species produce during the pairing season." The "humming" is, of course, due to the rapid vibrations of the wings. Of their intelligence little is known except that in connection with nest-making, but there it seems certain. For they sometimes depart from what may be called the instinctive routine ; thus, they have been known to use a stone or a piece of clay to weigh one side of a hanging nest that threatened to turn turtle.

Whatever may be the mental aspect of nest-building—a mingling of instinct and intelligence, we think—the humming-birds' nests certainly show exquisite architecture. Many are about the size of an egg-cup, some not much bigger than the end of a driving-glove thumb. They are carefully felted structures in which fairies would love to slumber, for the materials are so delicate, the cottony down of plants interlaced with gossamer, and compacted outside with pieces of lichen and leaf. Most are like cups, some are like turbans ; most are saddled on twigs, some are hung on the ends of long-pointed leaves—more or less out of reach of monkeys ; and some that resemble hammocks are swung on to the face of cliffs by means of spiders' webs !

The nests are so well disguised that they are rarely detected except by accident or when the bird is seen flying off. There are always two eggs, nearly dead white, and somewhat oblong. They look like little peas, but it must be noted that they are large for the size of the bird. They require twelve to eighteen days' incubation, and there are usually two broods in the season.

We see, then, that these pigmy birds—some hardly bigger than humble-bees—have found a large niche for themselves

in the crowded world; they have few enemies; they find their food easily; their nests are not readily detected. For these and other reasons they are probably relieved from very severe sifting in the struggle for existence, and this relative freedom has allowed them to blossom out exuberantly like the flowers they visit.

THE HORNBILL

Many of the birds of the tropical forests have strong bills for cracking hard fruits, but few have such a mighty weapon as the beak of the noisy-winged hornbill, that flies high over the trees uttering its strange cackling cry, which has been described as between the tooting of a motor-horn and the braying of a jackass. In its long, sharp, powerful bill the bird can seize and break up all sorts of food, from roots and fruits to a small tortoise, and it can also scoop out a hole in a tree to make a nesting-place. The story of the imprisonment of the hornbill is a very curious one. When the hen-bird has laid her eggs in the nesting-hole and is ready to sit and keep them warm till the young birds hatch out, she begins to plaster up the entrance with mud till only a small opening remains. Good observers say that she does much, if not most, of the walling-up herself, using materials (clay and resin) previously collected, and the meaning of her procedure is probably to protect herself and her brood from the attacks of malicious monkeys or climbing snakes. Other observers insist that the male bird builds up the prison-door from the outside. Probably both sets of observers are right. In any case the cock-bird is in close attendance.

The mother bird is not left to starve in her prison, for her mate feeds her through the little opening that has been left in the mud wall. He comes to the tree and gives a signalling knock so that the hen-bird raises her beak to the hole to receive a juicy fruit or perhaps a frog or a mouse. In some cases the food is done up in a thin skin moulted from the male bird's gizzard, and the packet has a quaint resemblance to a sausage. The cock-bird is so devoted, and works so hard to keep his mate supplied, that by the time the young birds have hatched out and the mother is ready to leave the

hole, he is sometimes almost worn to a skeleton. Occasionally he dies of exhaustion !

Another fruit-eating bird with a curious beak is the brilliantly coloured Toucan of Tropical America. The huge orange bill is flattened from side to side, and is shaped like the claw of a lobster. Although it is very large it is not heavy enough to hamper the Toucan's flight, and it is a very useful instrument when it comes to picking fruit. The rather heavy-bodied bird is able to sit securely on a comfortable branch and gather fruits from even the slenderest twigs all around it with the tip of its enormous bill.

THE HOATZIN

Gleaming sun-birds of Africa ; humming-birds like living gems darting through the forests of South America ; and beautiful birds of paradise in the jungles of New Guinea ; the brilliant birds of the tropics would make a very long list ; but, to the naturalist, there is no bird of the jungle and swamp more interesting than the hoatzin. This curious bird, which is found in British Guiana, is a living link between reptiles and birds. In many of its ways it is much more like a reptile than like any other flying bird. " For it," as Mr. William Beebe says, " the dial of the ages has moved more slowly than for the rest of organic life . . . and in their classic reptilian affinities—voice, actions, arms, fingers, habits—they bring close the dim epochs of past time, and renew for our inspection the youth of bird-life on the earth."

Hoatzins always build their nests over the water, in trees at the edge of a lotus-covered swamp or along the banks of a river. The nests are scarcely more than platforms of dry sticks, only slightly hollowed out, and often not very securely put together. They are usually from six to fifteen feet above the water, sometimes less and occasionally very much more, even fifty feet up a tall tree. The birds are extraordinarily tame, and will not leave the nest till the branch on which it is built is actually shaken by the intruder. A bird sitting on the same branch as one which is shot will calmly go on preening its feathers, without so much as a



Photo: Reproduced from "Jungle Peace," by William Beebe, by courtesy of Messrs. Henry Holt & Co.

NESTLING HOATZIN CLIMBING WITH THUMB AND FOREFINGER.

The Hoatzin (*Opisthocomus*) is a survival of an ancient stock of birds. Anatomically regarded, it might be called a "living fossil." One of the antique features, reminiscent of arboreal reptiles, is the gripping of the branch with the bird's thumb and forefinger.

glance at its companion's falling body. But when at last the parent-birds do realise that their nest is being tampered with, they begin to croak in their strange, hoarse voices. The female's voice is deeper than the male's, with a more gurgling sound, but the usual note of both is something like a frog's croak. "At last," writes Mr. Beebe in his

delightful book, *Jungle Peace*, "the never-to-be-forgotten hoarse gutturals of hoatzins came to our ears, and dimly through the rain we saw one small branchful of four birds, bunched up with drenched plumage. Two others were posed as rain-worshippers—rufous wings wide-spread, heads stretched out, welcoming the sheets of water which poured over them. Their wild crests, though sodden and glued together, were still erect, dripping and swaying."

The home of the hoatzins is in the thorn trees or "pimplers," which grow right down to the mud that is washed by the brackish tide of the river estuary. The trees are covered with big thorns, their flowers are delicate, Wistaria-like, pale mauve blossoms, and their leaves, which form the food of the hoatzins, are soft and green. Among these trees the birds spend their time, building their nests in the forks of the branches, and sitting close on the eggs. When the heat is intense the mother-bird sits on the rim of the nest so that her body casts a shadow on the nestlings. Year after year they remain in the same place, owing their safety to their strong, musky odour, which keeps possible enemies at a distance.

Mr. Beebe describes how a week-old hoatzin chick, whose life had till then held "nothing but siestas and munchings of pimpler leaves," behaved when its scared mother forsook the nest and it was left alone to face the intruders. As its head, with beady black eyes and thick, blunt beak, and its long, thin neck appeared over the edge of the nest it looked extraordinarily like some extinct reptile of past ages. Its body was covered with scanty, sooty black down ; on its head the slightly longer down already suggested a crest, but its flight-feathers were only half an inch long, so it had no chance to escape by flying. But the young hoatzin has a free thumb and forefinger, which it can use in climbing till its wings are strong enough for flight ; so the chick did not wait to be picked up by the man who was climbing painfully up the thorn tree and making the nest sway perilously. It took a few uncertain steps to the edge of the nest that it had never left before and raised its mittened hands. The brave little hoatzin began to climb, using its feet and its thumbs

and forefingers, and craning its neck like a tiny turtle. With many a twist and turn it reached the end of a branch. It was almost within the climber's grasp. Then it played its trump card, and did what no other modern land bird would do. " The young hoatzin stood erect for an instant, and then both wings of the little bird were stretched straight back, not folded, bird-wise, but dangling loosely and reaching well beyond the body. For a considerable fraction of time he leaned forward. Then without effort, without apparent leap or jump he dived straight downward, as beautifully as a seal, direct as a plummet and very swiftly. There was a scarcely noticeable splash, and as I gazed with real awe, I watched the widening ripples which undulated over the muddy water—the only trace of the whereabouts of the young bird."

After some minutes the bedraggled little bird reappeared, but when they rowed towards it, the chick dived again, and came up in the middle of a tangle of weeds, well out of reach. The glistening black nestling then began to climb back to the nest fifteen feet above water, and never faltered till it tumbled into the cradle, when it uttered a pitiful cry. The mother bird had been urging it on for the last few minutes with hoarse cries, and now she was ready to comfort it and stuff its little crop full of soft " pimpler " leaves.

Mr. Beebe sums up the story of the baby hoatzins in this way : " They crept on all fours, they climbed with fingers and toes, they dived headlong, and swam as skilfully as any Hesperornis of old. This was, and I think always will be, to me, the most wonderful sight in the world. To see a tiny living bird duplicate within a few minutes the processes which, evolved slowly through uncounted years, have at last culminated in the world of birds as we find it to-day—this is impressive beyond words."

THE STORY OF THE BOWER-BIRD

Many birds make very beautiful nests; that of the chaffinch, for instance, is a masterpiece. But part of the beauty is also useful, since it makes the nest a soft and yet

safe cradle for the young birds. In Bower-Birds, however, there is a very strong fondness for pretty things which are of no direct use. The beauty seems to be enjoyed for its own sake. Not only do the birds make bowers or arbours that are attractive in themselves, they decorate these in a charming way. The bowers are courting places ; they are made long before the birds come together as mates ; they have nothing to do with the nests, which are always built on trees and are quite ordinary constructions.

Bower-Birds are closely related to Birds of Paradise and not very distantly to crows. They often show handsome plumage, but they are not to be compared with the gorgeous male Birds of Paradise. They are forcible rather than melodious in their " song." What they lack in brilliance and music they make up for by the decorations of their bowers. There are many different kinds, but they are confined to Australia and New Guinea.

Let us begin with a simple case, that of the Saw-Billed Bower-Bird (Scenopoeetes). It clears a circular space around a tree, removing all the twigs, leaves, and stones. Around the circumference it sticks in tendrils of a climbing palm, bending them inwards. Then it seeks for leaves that are silvery on the lower side and arranges them regularly on the cleared ground, with the bright surface up. Then the bird perches on the tree overhead, but every now and then it jumps down to replace a leaf that has been blown away or to turn up the silvery surface of one that has been blown upside down. In this case one promenade or playing ring is made by the male bird and another by the female, and this happens about a month before the mating. The female sits on a branch, quietly awaiting a visit from a suitor. The male energetically invites a call, for he gives utterance to an extraordinary song, consisting mainly of snatches borrowed from other birds, and even from insects such as grasshoppers and cicadas. He continues this all day except when he jumps down to strut about the ring or to replace a leaf that has become shrivelled. The birds often require to exert considerable force to get a leaf that they fancy separated from its tough stalk.

The arrangements made by the Satin Bower-Bird (Ptilonorhynchus) are more elaborate. The bird is about the size of a magpie, the male glossy purplish-black, the female chiefly greyish-green, and the two seem to make the bower between them. There is in the first place a sort of platform of twigs raised a few inches off the ground in a clearing. On this there is built an archway of twigs, sometimes open, sometimes closed, at the top. This arch or arbour may be several yards long, but it is just high enough to let the birds run about freely. It is often festooned with creepers. But there is something more, for in front of the entrance there is a "beauty feast," namely, a miscellaneous collection of snail-shells, blanched bones, bright feathers, and so forth, which are gathered from the country round about. An interesting point is that the birds, who are not in any hurry, spend a good deal of time in trying various arrangements of their spoils. The male chases his desired mate in and out of the arbour; he struts and bows and displays his fine feathers; both birds seem to be full of glee.

A recent observer describes the bower as like an arch turned upside down, open at the top, standing in a little glade, with ferns and shrubs forming a natural fence. Before the entrance there were bleached bones, some land-shells, several blue feathers from parrots, bits of blue glass, and about a score of flowers, chiefly violets. "To gather the blossoms the Bower-Birds must have visited a settler's garden, two or three miles from the scrub."

In a clearing, sometimes under a beautiful bush of red Bougainvillea, the Collared Bower-Bird (*Chlamydodera nuchalis*) makes a long arbour raised on a low platform. They are soberly coloured grey-brown birds, except that they have an iridescent red-violet collar, usually more brilliant in the male. But what they lack in colour themselves they make up for by what they gather. In front of the arbour the ground is strewn with brightly coloured flowers, red berries of the Blue Gum, whitened skulls of small mammals, bright feathers from other birds, shining pods and shells. If they are near some deserted gold-digging settlement they may add to their display broken

pieces of glass and even empty tins. They are evidently attracted by what is brilliant. We read that a museum specimen of the bower included more than half a peck of decorations. "They consisted principally of a large white



Photo by permission of The Natural History Museum, South Kensington.

A PAIR OF CRESTED BOWER-BIRDS,

showing the difference between the gorgeously crested male and the less decorative female.

univalve; the shells of a large land-snail, of which there were in all about four hundred; shining stones, principally flints and agates; bright-coloured seed-vessels and pods; bleached bones of small quadrupeds, and other objects of interest." The male bird struts about in the show as if he got some reflected glory from his collection, and he

becomes more and more excited. At last, for some reason best known to himself, he seizes a particularly fine object in his beak—it may be a leaf or a flower or a feather—and waving it aloft rushes at his playfellow with quivering wings and chases her in and out of the bower. By and by they go off together to build a nest in a tree.

In another kind of Chlamydodera the platform of interwoven twigs is four inches high, and the bower proper from sixteen to twenty inches. There are the usual decorations, including shells brought from the seashore some miles away. The male bird indulges in the usual showing off, dancing and jumping in great glee. In one case it was noticed that he carried about day after day a long dry reddish centipede, which had struck his fancy. He held it in his beak and waved it about as if it were a flag. It is very difficult to imagine what this kind of behaviour means, whether the bright object is a " symbol " of the bird's love, or is merely something to flourish about, like a cane. In the case of this particular Bower-Bird, as many as half a dozen visitors have been seen in the bower, but, again, we have to confess that we do not understand. One male holds the stage at a time, and in the long run the outcome is as usual, that a pair of birds fly off to a tree to nest.

In his interesting book, *In Australian Wilds* (1919), Mr. Charles Barrett describes one of the bowers to which we have just referred. " Beneath a straggling clump of boxthorn was the bower of a pair of Spotted Bower-Birds (*Chlamydodera maculata*). It was neatly and strongly built. At either end was a collection of bright objects—bleached bones, pieces of weather-worn glass, green and blue, some blue feathers, fresh glossy leaves, a few red berries, a bit of perforated zinc, and other odds and ends that the birds had gathered from far and near. Conspicuous among the Bower-Bird's treasures were five glass bottle-stoppers and a big pellet of lead. Through and through their bower the builders ran, tossing about the bones and other objects, and evidently delighting in the play."

The *largest* bower is made by Newton's Bower-Bird (Prionodura), which arranges an arbour of sticks between

two trees, and roofs in the space with creepers, embellished with white moss, ferns, and flowers. It may be ten feet high and eight broad. The main bower has annexes of dwarf hut-like structures, but no one knows what these mean. There are many puzzles in the ways of Bower-Birds.

But the *finest* bowers are those of the Gardener Bower-Bird (Amblyornis), which differ widely in different species, but are always extraordinary. Dr. Beccari has given a good account of love's labour in the New Guinea Gardener (*Amblyornis inornata*), a plain, ruddy bird about the size of a thrush. This Bower-Bird chooses a spot centred in a small shrub towards a yard high. Around the base of this it builds up a cone of interwoven mosses, which may serve to strengthen the central pillar. It then takes the slender upright branches of a tree-orchid and arranges them like rafters with one end in the ground and the other on the top of the central bush. The result is a conical cabin, about a yard in diameter at the ground. The radiating, almost straw-like rafters retain their leaves for a long time without their withering, as is often the case with orchids that grow as perched plants on trees. So much the better for the bower. But this is not enough. The slender rafters are bound together by more delicate twigs, and moss is added so that a well-made and beautiful roof is eventually formed. Between the base of the central pilaster and the insertion of the lower ends of the rafters in the ground there is a vacant space—the run—almost circular, in reality horseshoe-shaped.

But this is not all. Directly in front of the entrance to the cabin there is "a miniature meadow of soft moss, transported thither, kept smooth and clean, and free from grass, weeds, stones, and other objects not in harmony with its design. Upon this graceful green carpet are scattered flowers and fruit of different colours, in such a manner that they really present the appearance of an elegant little garden." The collection may include brightly coloured toadstools and insects, and some of these are strewn about in the interior of the cabin as well as in the garden. As is usual, everything that withers and shrivels is removed, and replaced by fresh material. The "garden" is often larger than the

"cabin," and its meaning is the same. It expresses a pleasure in pretty things, and that pleasure has been linked on to love-making. The nest is just as usual—a simple affair on the branch of a tree.

What does it all mean? The making of the bowers requires time and energy and carefulness; the bright objects are often carried for miles; they are not scattered about anyhow, but experiments are made in their arrangement.

Perhaps we may draw two conclusions. The appreciation of bright things that is shown by jackdaws and some other members of the crow family reaches a high level in the Bower-Birds. They have the beginning of our own delight in the beautiful. But it is linked on to love-making. The exhibition of beautiful objects is used to express and to excite love, and is probably connected with the fact that the male Bower-Birds are rarely brilliant and never melodious. It comes to this, that the "beauty-feasts" are forms of art, expressive of love. In preparing them the birds are bound to one another by ties of feeling which last through their married life.

BIRD PEDIGREE

Those who study plants and animals to-day have this great advantage over their predecessors before Darwin's time, that they look at everything in the light of history. Every complicated creature is the long result of time. Unless it is on the downgrade like a parasite, it sprang from simpler ancestors, and these sprang from others simpler still. The plants and animals of the Carboniferous ages, when the great coal-measures were laid down, were in many cases very complex and well-controlled organisms (or living creatures), but, on the whole, they were simpler than their descendants—the plants and animals of to-day. Thus, in those days there were not as yet any reptiles, birds, or mammals. In the course of ages, life has been slowly creeping upwards. There have been some slowly changing creatures; there have been others that have slipped down the ladder of evolution; but, on the whole, as the result of

millions of years of changing and sifting, trying and testing, there has been an advance of life, something like what man calls progress.

Thus there are convincing reasons for believing that birds sprang from reptilian ancestors, active, high-strung, scaly creatures that ran swiftly along the ground and took running leaps on to the lower branches of trees. Let us outline these reasons, for there seems little in common between the grovelling, cold-blooded reptile and the soaring warm-blooded bird: (1) The oldest remains of birds that are preserved in the rocks belong to a creature about the size of a crow, called Archæopteryx, whose skeleton presents many interesting features. There were teeth in both jaws, for instance, and no modern bird has even traces of teeth. There was a long lizard-like tail of twenty-six vertebræ (or backbone bodies), and no modern bird has more than a very short stump of a free tail, apart, of course, from the feathers, which do not count. There were three clawed fingers and the wing was what might be called half-made. Yet Archæopteryx was a genuine feathered bird. It is an historical relic, long since extinct, but linking the class of birds back to an extinct ancestry in the class of reptiles, in the order Pseudosuchia.

(2) Although there are great differences between every bird and every reptile, it is very interesting to find in the structure of birds numerous features, both big and little, which betray their pedigree. Thus all birds have some scales, especially on or near their toes, which are exactly like the scales of reptiles. And when we find that many birds, like the albatross, have what is called a "compound" bill, made up of a number of separate horny pieces, we may convince ourselves that these correspond to the scales on the jaws of reptiles. Such a little peculiarity as the annual shedding of the outermost covering of the bill in puffins comes to have a great historical interest, for it corresponds to the moulting of the outer covering of the scales in reptiles. On the other hand, the moulting of the bird's feathers marks something new, for reptiles do not moult their entire scales, to which feathers in a general way correspond; they

simply moult the dead outermost layer of the skin which extends over the scales.

In many birds the front of the eye shows a ring of bone or a circle of minute bony plates (the so-called "sclerotic ossicles"), which strengthen the eye just where the transparent cornea (stretching like a blind over the front) joins the firm protective envelope (sclerotic) that extends round the back of the eye. This bony ring is not a very important feature, but it is seen in some extinct reptiles, and it is part of the bird's legacy from its reptilian ancestors.

(3) A third line of proof that birds sprang from a reptile ancestry is to be found in the study of development. It would be easy to palm off the eggs laid by many a reptile for those laid by birds. Thus the egg of a crocodile is not very different from that of a goose, or that of a tortoise from a pigeon's. If we break the limy shell of the two kinds of egg we find inside the same "white of egg" and the same sphere of yolk with a little drop of living matter lying at its upper pole. For the first week or so, the development of the embryo bird, best known in the case of the chick, is very like that of the embryo reptile. It looks as if they progress side by side along the same high road, until they reach a parting of the ways, when the one diverges to become a reptile, and the other to become a bird. In both cases the embryo is surrounded by the same birth-robes, the protective amnion which forms an elastic dome of fluid over the delicate young life, and another hood, the allantois, which has many blood-vessels and has mainly to do with *breathing before birth*. It is spread out underneath the shell, and its blood-vessels absorb oxygen through the pores. If the egg-shell be varnished so that the pores are closed the embryo bird or reptile must die of suffocation.

Another interesting point concerns the gill-clefts—minute slits which are seen on the sides of the neck in embryo reptiles and birds. There is no doubt that they correspond to the gill-clefts which are used in connection with breathing in fishes. They are openings from the pharynx (the muscular part of the food-canal immediately after the mouth-cavity). In fishes the water passes through

them and they are bordered by the somewhat feathery gills on which the blood is spread out. But in all backboned animals above amphibians the breathing before birth is discharged by the allantois, the birth-robe already mentioned (forming part of the placenta in ordinary mammals), and the gill-clefts are of no use for breathing purposes. Indeed they do not seem to be of any use at all, except that the first one becomes the " Eustachian tube "—which leads from the ear-passage to the back of the mouth. Now the interest of these gill-slits is great: they are relics of the ancient fishes which were ancestral to all other backboned animals; they show how the past lingers in the present; and they are practically identical in embryonic reptiles and birds. In a few embryos of reptiles and birds a recent investigator has found in the gill-clefts several minute tags or filaments, which are almost certainly vestiges of the long-lost *gills*. At the tip of the bill in the newly hatched bird there is often a whitish hardening of horn and lime which goes by the name of the "egg-tooth," though it has no connection with teeth. This hardening is used by the unhatched young bird as a hammer for breaking off the broad end of the egg-shell. The young bird, being ready to emerge, becomes restless; it convulsively straightens its head in a rather complicated way, and hits the inside of the shell. It shrugs itself a little, altering its position, and hits the shell again at a new place. If its strength lasts it may succeed at the first trial in breaking open the prison-doors; if it gets tired it will have to rest, perhaps till the next day. Here again we have an interesting structure—the egg-tooth. It does its work well, but it is only used once in the life-time, for it falls off a few days after hatching. But it is particularly interesting because it occurs in some reptiles, such as the crocodile. It is a trivial thing, but it is part of the legacy which birds inherited from reptiles. It is a straw which shows how the evolutionary wind has blown.

Many other examples might be given which prove the blood-relationship between birds and reptiles, but we have given enough to show what is meant by saying that every creature must be considered in the light of history.

XVIII

THE WAYS OF REPTILES

FOR many millions of years the highest animals were Reptiles, there being no hint as yet of Birds or Mammals. But the ancient Reptiles were for the most part very different from those that are living to-day ; some were giants (the thigh-bone of Atlantosaurus was six feet long !) ; many lived in the sea ; some were able to fly a little (the Pterodactyls, from the size of a sparrow to that of an albatross) ; some were bipeds, and so on. Most of these ancient scaly creatures disappeared without leaving any direct descendants ; others led on to the crocodiles, lizards, snakes, tortoises, and other Reptiles that are now living, the most old-fashioned of all being the " New Zealand Lizard " or Sphenodon, the sole survivor of a lost race, and therefore sometimes spoken of as " a living fossil." Even more important, however, is the fact that from different stocks of extinct Reptiles there evolved the Birds and the Mammals. In regard to these we have said so much that we cannot do more than give a few illustrations of Reptilian ways.

As Reptiles, Amphibians, and Fishes are cold-blooded, tending towards the temperature of their surroundings, they are more in the grip of their surroundings than birds and mammals are, and have not so much freedom of behaviour. Moreover, in proportion to their size, their brains are smaller, and the part which is the seat of intelligence is not nearly so well developed as in birds and mammals. So one must not expect them to have such interesting ways as the higher backboned animals.

There is nothing very remarkable about the senses of reptiles. Touch counts for much in snakes where it has its seat in the quivering forked tongue, which is shot out

and flicked in very rapidly and very frequently. The snake tests everything with its restless tongue. Vision is often acute in reptiles and it is interesting to watch the precision with which a chamæleon measures the distance—sometimes seven inches—from which it can strike an insect with its long protrusible tongue, swollen like a club at its tip and very sticky.

Many reptiles have an acute sense of hearing, as is well illustrated by the Madagascar crocodile. The mother deposits her eggs, which closely resemble those of a goose, deep in the warm sand, twenty to thirty in one nest. Sometimes they are two feet below the surface, and it would be awkward indeed if they hatched there. But when, after twelve weeks, the young one is ready to come out of the shell it makes a hiccough-like sound, which the mother, who often sleeps on the top, understands as a signal. She digs away the earth so that the young crocodiles are not buried alive. A naturalist once surrounded the nest with a fence, which the mother partly destroyed. A stronger one was made, but the mother dug a ditch below it, and although she did not get in herself, she managed to get her children out and took them to the water. The same naturalist put some crocodiles' eggs in a box in his room, and covered them with two feet of sand. When he walked past or tapped on the box the young crocodiles uttered their piping sound. Perhaps they hear their mother's movements, though they cannot know what they mean. We may mention here that the young crocodile has an "egg-tooth" on the tip of its upper jaw which is used like a borer in breaking through the shell. It falls off when the creature is two weeks old. Another peculiar thing is that the newly hatched crocodile is so big for the size of the egg. This is rather a puzzle The egg is a little over three inches long, but out of it come a baby crocodile of eleven inches. Of course it is bent upon itself inside the egg—but even then!

The young crocodile utters its sound *instinctively*, that is to say, as we have seen, it is part of its inborn equipment to give this signal. It does not require practice or learning; and it does not need to understand what it is doing. There



Photo: H. J. Shepstone.

ALLIGATOR'S NEST.

The "nest" of the alligator is a mound of water-soaked twigs and moss, and may contain about forty eggs, each from 2 to 4 inches in diameter, which are deposited in layers among the rotting plants. The heat produced by the fermentation helps the development.

is a great deal of instinctive behaviour among reptiles, and we shall take as an example the American "soft-shell" tortoise, whose technical name is Aspidonectes. It is a powerful swimmer and hunts among the freshwater weeds for crayfish and insect larvæ. But it is quite at home on land, and covers the ground so quickly that it can hardly be overtaken by a man running. It is fond of basking on a floating log, and always lies facing the water, so that no

times is lost if danger threatens. At the onset of winter it rocks itself to and fro in the soft mud, sinking deeper and deeper until it is below the frost-line. There it lies low for months.

The female is very careful in choosing a suitable place for egg-laying. She scrapes a hole in the ground, lays a number of eggs, covers them with moist earth, lays some more in an upper tier, and then tramps firmly over them. If she is disturbed during the egg-laying, she tries to cover them up before she goes. Now all that this turtle does in its ordinary life is done in the same way by them all. This is routine instinctive behaviour.

But another note is struck when a reptile *learns* something, no matter how simple. This is illustrated by some interesting experiments which Professor Yerkes made with the small-speckled turtle. It is one of this creature's instincts to snuggle into a dark secluded corner. Like many of its relatives it is, so to speak, wound up to seek out such places. What Professor Yerkes did was ingenious. On the road leading to the turtle's dark nest of damp grass, he put a maze which the turtle had to traverse if it meant to reach home. The maze consisted of a box about a yard long divided by partitions into four compartments with suitable doorways between. The turtle, making for home, entered the maze and was much puzzled. It wandered about in a futile sort of way for thirty-five minutes, and at last, more by chance than good guidance, it managed to get through. Two hours later the experiment was repeated, and on the second trial the turtle reached its nest in fifteen minutes. There was much less wandering in the maze.

Experiments were made every two hours. On the third trial the turtle only required five minutes, on the fourth three-and-a-half. From the fourth trial onwards the path ceased to be irregular. The tenth trial was made in three minutes five seconds, with only two mistakes in turning. The twentieth trial took only forty-five seconds, the thirtieth forty seconds, the fiftieth thirty-five seconds. Both in the thirtieth and fiftieth trials the course followed was quite direct; the turtle had learned its lesson.



Photo: F. W. Bond.

YOUNG ALLIGATOR EMERGING FROM THE EGG.

Before it is hatched, the developing alligator breathes through the porous egg-shell It breaks its way out, very much as a chick does, and it is soon ready for the usual business of life, being fully equipped from the first.

We need not credit the turtle with much intelligence in all this, but it is plain that it profited by experience. Perhaps it learned to get quickly through the simple maze somewhat in the same way as we learn to play certain games of skill, such as golf. It gradually got rid of futile movements.

A newly hatched crocodile will snap at your finger, but this is not intelligence. It is the kind of action

called *reflex*, such as we illustrate when we shut our eye on the approach of a stone. A newly hatched turtle will make for the water in the darkness, and if you turn its head the wrong way it rights itself. But this is not intelligence. It is an engrained obligation, something like the moth's attraction to the candle flame. From amid the pathless sea, the fish-eating turtle finds its way, year after year, to the same sandy island. We do not understand this "homing," but it is not due to intelligence. There is some memory in the "homing," and there are records of snakes remembering people after an absence of six weeks.

There is a large American lizard called the Iguana, usually a gentle creature, which has been known to defend its mate with fury and with what would be called courage in man. So there may be more feeling slumbering in the reptile than one is inclined to think; and the same may be true in regard to their intelligence. Let us consider this question with particular reference to snakes.

SNAKES

There is a widespread belief in the wisdom of the serpent or snake, but it does not seem to have a very strong foundation in fact. No doubt these strange limbless reptiles are very effective in movement, food-capture, attack, and escape, but their wisdom is far to seek. What they do is the outcome of engrained hereditary capacities which work well—not so much instincts as simple answers-back to everyday questions. They do not give much evidence of inventiveness or plasticity; their intelligence seems to be of a low order. We must remember, however, that when an animal's inborn equipment is sufficient to enable it to cope with nine out of ten difficulties in everyday life, it is not likely to give evidence of much understanding. It is rare for an animal to show more intelligence than it needs.

But even when the mind of the snake finds some expression, it is not what one would call brilliant. This may be illustrated by one of the most flattering records, a

story told by Layard of a cobra in Ceylon. This snake had thrust its head through a narrow aperture and swallowed a toad. This was effective enough, but the narrowness of the opening prevented the snake withdrawing its head when it was expanded with the booty. So it had to disgorge the toad, which naturally tried to get away. "This was too much for snake philosophy to bear, and the toad was again seized; and again, after violent efforts to escape, was the snake compelled to part with it. This time, however, a lesson had been learnt, and the toad was seized by one leg, withdrawn, and then swallowed in triumph." Perhaps the word "triumph" is a little like "reading the man into the beast," but it will be generally admitted that mind was stirring in that cobra. It would have been satisfactory if the experiment had been made of repeating the situation, for it would have been interesting to discover whether the cobra would seize the second toad by one leg at the very start. For if it did so, there would be convincing proof of *intelligent learning*. There may have been a good deal of luck in reaching the first solution.

As to senses, we have already referred to the restless tongue which is whipped out and in as a touch-organ. The eyes are well-developed, though lacking one of the usual muscles—the retractor. The risk of injury when the animal is creeping among obstacles is lessened by a complete transparent blind over the front of the eye. They have no drum to the ear, and it is safe to say that hearing does not count for much in their life.

Why are snakes believed to be so wise? We must find the basis for this generosity in the dread and respect with which they are regarded by simple people. And the dread and respect must be due to the mysterious movements of the animals, their elusive ways, and their frequent deadliness. From very early days, at any rate, snakes have been symbols of the dæmonic powers of the earth, and it is one of the ways of primitive man to credit a symbolic animal with the virtues or abilities of the Power which it symbolises. So it comes about that the serpent gets credit for greater subtlety than any other beast of the field, and what seems to us a

somewhat commonplace mind has been invested with extraordinary wisdom—a generous exaggeration.

Snakes have been given credit for doing many things that are impossible or vastly improbable. In spite of the assurances of eye-witnesses, it is impossible that a snake should put its tail in its mouth and make a hoop or wheel of its body. It can't be done.

It is said that one snake may begin to swallow another



Photo: W. S. Berridge, F.Z.S.

WATER MOCASSIN SNAKE (*Ancistrodon piscivorus*).

A semi-aquatic snake, with a stout heavy body and abruptly tapering tail. A common size is about four feet long; a common colour is dull olive with blackish blotches. It is a very omnivorous and very deadly inhabitant of North American lagoons.

which is at the same time engaged in swallowing it; and it has been recorded that two snakes may meet in the middle of a victim that they are both swallowing. But one must not swallow all the snake-stories one hears. Over and over again the story crops up that a mother-snake has been seen to swallow her young ones temporarily, so as to save them from great danger. But no criticised account of this has been given. Sometimes the observer has killed the snake and opened it and found young ones inside, and, unaware that

some snakes bring forth their young as little snakes (viviparously) and not inside eggs (oviparously), has leapt to the conclusion that the mother had saved its offspring by swallowing them for the time being. Yet when one remembers that among fishes and frogs there are cases known where the male parent at the breeding season always shelters the eggs and the young ones inside his mouth, one is not inclined to call this snake-story impossible or incredible. What one may say is that it is vastly improbable.

There is also reason to be very doubtful in regard to the widespread belief that snakes are susceptible to the soothing influence of music, and that the Hindu snake-charmers take advantage of this in dealing with the cobras they carry about in baskets. The poor cobra has had its poison-fangs wrenched out, and in many cases at least its movements in the snake-charmer's hands are made under compulsion.

It was a better trick that the magicians played long ago before Pharaoh, when they turned snakes into sticks and back again. This trick illustrates the strange state called " animal hypnosis " into which it is possible to send many animals, from crayfishes to hens. It is a peculiar fatigued state of the nervous and muscular systems, not yet fully understood. The snake is held firmly by the tail and just behind the head. Orders pass out from the brain and spinal cord commanding the muscles to contract. But the snake is held firmly and no proper contraction is allowed. The orders keep coming, but the muscles cannot obey them, and a peculiar state—a sort of contradiction in terms—sets in. The animal becomes stiff and motionless ; it lies quietly without being held. The state is quite different from the hypnotised condition in man, but there is something in common. In any case the snake " becomes a stick " and remains a stick for a long time. By and by the blood begins to circulate freely, the fatigue effects pass off, the wheels begin to go round again, and the stick becomes a snake. But there is no wisdom here.

Perhaps the same should be said in regard to those snakes that feign " death " when they are suddenly and hopelessly

cornered. It is probable that their state of "lying low" is closely akin to animal hypnosis. It is a condition into which the animal passes, reflexly not reflectively, when it gets a sudden shock or is quite baffled. It is in all likelihood at a much lower level than the "playing 'possum" exhibited by a genuinely clever animal like a fox, where real feigning is not out of the question. We must admit, however, that



Photo: W. S. Berridge, F.Z.S.

ELEPHANT-TRUNK SNAKE OR JAVAN WALL-SNAKE (*Achrochordus javanicus*).

This is a very peculiar olive-brown snake, with no specialised ventral shields, an absence which may be associated with the aquatic habits. The scales are small and the flat head is covered with granules. It attains a length of four feet and feeds on fishes.

there are experienced naturalists who take a more generous view of the snake's behaviour. Thus, in speaking of the common Hog-nosed Snake of the New England States, which will hang inertly like a piece of rope if you carry it, head downwards, by its tail, Dr. Hornaday says: "Of course it hopes to escape by its clever ruse, and, no doubt, it often does so from the hands of inexperienced persons." There is no doubt that the peculiar answer-back may save the snake's life, but there is no proof that it is a clever ruse,

and we may doubt whether the Hog-nosed Snake or any other snake ever hopes for the best or dreads the worst.

Dr. Hornaday is Director of the New York Zoological Park, and has a large experience of snakes and of many other animals. It is fair, therefore, to notice that he does not share our view of the snake's very limited intelligence. In his *Minds and Manners of Wild Animals* (1922) he speaks of " the keen intelligence and ratiocination " of snakes. He bases this belief on " the success of all species in meeting new conditions and maintaining their existence in face of enormous difficulties." But efficiency, which no one doubts as a quality of snakes, is not the same as intelligence, and alertness is not " ratiocination," which really means a chain of reasoning.

Telling of his experience, Dr. Hornaday says again : " I have emerged with a fixed belief that of all Vertebrate creatures, snakes are the least understood, and also the most thoroughly misunderstood. The world at large debits serpents with being far more quarrelsome and aggressive than they really are, and it credits them with knowing far less than they do know." He attaches great importance to the case of a Reticulated Python, twenty-two feet long, which had been, on its long journey from Singapore, " unable to shed its old skin on schedule time," and had to be *peeled* to save its life. At first it writhed and resisted, but the five keepers " worked quietly and spoke soothingly," and all went well. " For a long hour or more, and even when the men pulled the dead scales from the eyes and lips, the creature made no resistance or protest. I have seen many people fight their doctors for less. That wild, newly caught jungle snake quickly had recognised the situation, and acted its part with a degree of sense and appreciation that was astounding. I do not know of any *adult wild* mammal that would have shown that kind and degree of wisdom under similar circumstances."

Of course, a good deal depends on what is meant by the word " wisdom," but it is open to doubt whether the python was as intelligently acquiescent as Dr. Hornaday believed. There was a good deal in its condition to lead it to

non-resistance. Our general view is that snakes have a good many engrained or inborn ready-made ways (reaction-capacities), which are sufficient for the ordinary problems of life, and that when something quite unexpected happens they manage to wriggle out of it with credit. If they were less efficient, they might, perhaps, be more intelligent.

There is another power that snakes are often said to have—the power of fascinating birds. We have watched what happens—a painful sight, even though full of scientific interest, and it seemed to be a clear case of fear-paralysis, such as many animals show. It looked anything but charming or fascinating. The birds seemed to be dazed with fear ; they moved stiffly and stupidly twice or thrice ; and then stood rigid. We have seen a pony so " fascinated " by a motor-car that we had to share in lifting it, like a frozen animal, off the road. So, even in regard to the so-called " bird-charming," what impressed us was the efficiency of the snake, not its wisdom.

THE ADDER

A prehistoric prejudice, established in the time of the " Cave-men," if not much earlier, keeps us from doing justice to snakes in general, and to the adder in particular. The practical justification of the prejudice is obvious in a country much beset with snakes, but even that should not keep us from giving the adder or viper the tribute of admiration that is its due. The shape is pleasing, with the head broader than what we may call the neck, and with the body tapering to a short tail. There is an interesting individuality in the adder's colouring and markings, *e.g.*, the cross on the back of the head, and we agree with Petruchio that " his painted skin contents the eye." No one can fail to appreciate, at least, the celerity of the creature's movements ; and surely they are very beautiful—the sudden straightening of the sinuous line which jerks the body forwards, and the ordinary " rowing on the ground with every rib for an oar." " Startle it," said Ruskin, " the winding stream will become a twisted arrow,

and the wave of poisoned life will lash through the grass like a cast lance."

The tips of a pair of ribs are attached to each of the large ventral scales which run across the under-surface of the snake. Certain muscles raise the scales so that their hind edges grip the ground, and then a certain number of ribs are moved so that the scales are brought into place again—the result being that the long body is pushed forward. It seems more like a multitudinous punting than rowing.

What a bundle of fitnesses is an adder! The shape is suited for creeping in the tangled herbage and between loose stones. All these ribs have changed a limbless creature into a millipede—and how quickly it disappears as we approach! Deep ball-and-socket joints and double articular processes give the numerous vertebræ great freedom of side-to-side movement without risk of dislocation. Everything inside the animal is adapted to the lengthening of the body, thus a broad organ like the liver has become long and narrow; and the kidneys are not opposite one another but in a line. There is not room for two well-developed lungs, so the left one is very small. The rush of air from the rapidly compressed right lung, when the snake is startled, accounts for the hiss.

On the other hand, no one could call the adder a neat eater. It kills mice and voles, slow-worms and small fledglings, newts and young frogs. Its hunting is at night. While one jaw grips the booty, the other is moved forwards and fastened: then the other side is loosened and advanced. So the adder gets outside of its victim, which often appears an almost impossible mouthful. In some cases the snake has to help its swallowing by pushing the protruding hind-quarters of its prey against a stone. When the victim has got past the mouth into the gullet, the downward passage seems to be helped by spasmodic movements of the ribs. One might think that the animal would choke during the laborious swallowing when the mouth is certainly as full as it can hold. But the front end of the windpipe is shunted forward, right out of the mouth, so that air can pass down to the lung. Not that an adder is easily choked anyhow.

The poison gland appears to be a transformed salivary gland, and the fang is a tooth folded upon itself so that a canal is formed down which the venom is ejected. This is Nature's way of transforming the old into the new. By a neat automatic arrangement the opening of the lower jaw, in preparation for striking, erects the fang on the upper jaw (maxilla), and leads also to the compression of the poison-gland. If the fang is wrenched out by a bad stroke, or reaches the end of its life-tether and falls off, there is another behind it ready to take its place, and behind that another on a smaller scale. There is indeed an indefinite succession of reserve fangs—providential from the snake's point of view. There must be an interesting anatomical moment when the front end of the poison-duct is connected with the base of a fresh fang.

The bile of the adder is an antidote to its own venom, a fact which may be useful to any one badly bitten who has presence of mind enough to kill the adder and extract and swallow the gall-bladder. We say "badly bitten," for there seems to be a waxing and waning of the poisonousness. When the adder is in good fettle and has not bitten for a while, there will be abundant poison available. To most adults the adder's snap means relatively little, but there are some people to whom even a fleabite is dangerous.

Every one knows about "the deaf adder that stoppeth her ear," for acquaintance with bad Natural History is wide-spread. But the adder is by no means deaf, and it has got no earhole which it could stop! There is no drum either, but the anatomical connections between the jaw and the well-developed inner ear are such that the adder must have a trombone accompaniment to all its meals. Like every snake, the adder stares at you, for the eyes are not movable, and the lids, which are mere vestiges in the embryo, come to nothing in adult life. What the eye looks through seems to be a fixed third eyelid, covered with a transparent horny scale like a miniature watch-glass, beautifully seen on the cast slough. We do not say that an adder sheds tears over a lost frog, but if it does then they must pass out by the nose.

THE SLOW-WORM

As another example of moorland animals we take the limbless lizard called the slow-worm (*Anguis fragilis*), one of the most interesting animals in Britain. It frequents dry grassy places where there is shade among the herbage or the heather, and an abundance of slugs. Often mistaken for a snake, and killed accordingly, it is, apart from its shape and limblessness, as unlike a snake as a reptile could be. Its scales are roundish and overlapping, very much the same over the whole surface of the body, and they have thin, bony plates below them—thus very different from a snake's scales. There is this resemblance, however, that the dead outermost layer of the epidermis covering the polished scales is moulted in a piece, like a snake's slough, being turned inside out from the head backwards, except that the tail is sometimes pulled forwards out of the dead husk, " like a sword out of its scabbard," as has been quaintly said.

The slow-worm has a long tail, whereas a snake has a short one; a slow-worm has always dwindling vestiges of the breast-girdle, which a snake never shows; the skull, the jaws, the ribs, and the soft parts are very different in the two types. It does not say much for popular Natural History that the slow-worm should also be called the blind-worm, for it has quite distinct eyes with movable eyelids, and one of the old zoologists describes them as " sparkling with pleasure " at the sight of a slug. There is more excuse for missing the ear-holes, for they are minute and well-hidden by scales. The tactile tongue is notched; not bifid like a snake's.

In the month of April or May, according to the climate and weather, the slow-worms awaken from their winter lethargy and emerge from their retreats. They pair and begin to hunt for food, which consists mostly of small slugs, earthworms, and caterpillars. They do not pounce or dart; but with slow movements they take what they can get. Though very shy and timid, they work by day, especially in shady places among the tall heather on the moor or in the herbage about the hedgerow. In August or September

the mother lays eight to twelve soft-shelled eggs, which open just as they are laid, liberating beautiful young ones like silvery worms, about an inch and a half long. To begin with, they feed on very delicate spiders and insects. In six weeks they have doubled their initial size, and in five or six years they are full-grown, usually about ten inches in length, nearly half of this being tail. There is an unusually large slow-worm in the British Museum seventeen inches in length. When the cold comes and food is scarce, there is a retreat to the recesses of a mossy bank or to some cosy chamber among withered leaves, or into soft, dry soil. As many as twenty may lie up together in their winter quarters, as if to keep one another warm, but probably because good places are used year after year.

To kill a slow-worm is rather contemptible ; first, because it is a very interesting product of evolution ; second, because it is a gentle, tamable creature with a distinct individuality ; third, because its backward bent teeth, though sharp, are not strong enough to draw blood, and the animal is innocence itself ; and, fourth, because from man's point of view it is useful in destroying slugs and small caterpillars. But nothing will persuade the average man that the slow-worm is not a snake, or that it is non-venomous. Even the learned will ask : Why is it called " Anguis fragilis " if it is not a snake ? and will perhaps quote a tag from Virgil *Latet anguis in herba.*

This limbless lizard, widely distributed in Europe and Asia, is interesting in many ways. It has the snake's shape, the two very distinct types being similarly adapted to similar conditions of life, such as gliding through narrow passages. To this kind of superficial resemblance between unrelated animals the term " convergence " is applied. The slow-worm stiffens when captured and readily surrenders its tail, as most lizards do, thereby often saving its life. This reflex or automatic self-mutilation is called " autotomy," and it is referred to in the specific name " fragilis," which Linnæus gave the slow-worm. It must be a very ancient reaction, for there is a pre-established weak plane where breakage is especially likely to occur. If

the surrender is successful, the lost part is re-grown at leisure, and though the new tail is rather a makeshift, the regeneration is a fine instance of the healing power of Nature.

Rising from the upper surface of the brain there is, as in many backboned animals, a parietal or pineal organ; and in the slow-worm, as still more markedly in that "living fossil" called the New Zealand Lizard (Sphenodon), it shows distinct traces of eye-structure. It may be a residue of an old-fashioned median upward-looking eye; in the slow-worm it seems to be still a sense-organ of some sort—perhaps susceptible to changes of temperature, for the creature is quick to get away from very sunny places, especially when it is young.

Lastly, the slow-worm is a fine example of what has been called the "cryptozoic" mode of life; it can easily efface itself; it is not rare, yet it is seldom seen; it survives because of its elusiveness, and that is an art in itself.

CHAMÆLEONS

The word chamæleon means "ground-lion," but most chamæleons are very markedly animals of the trees. They are genuine lizards, but their origin from the average lizard type is very remarkable. It must have been one of the most remarkable of the many transformations that have occurred in the course of the advance of life throughout the ages. It seems that the descendants of some sort of tree-shrew became bats, and that the descendants of some sort of pipe-fish became sea-horses; these were very striking transformations, yet neither seems to us so astounding as the evolution of a lizard into a chamæleon.

Every animal is a bundle of fitnesses or adaptations, but the chamæleon is a bag of tricks. We have watched them in South Africa, standing so still on the branch that we thought they had fallen asleep, and then all of a sudden, shooting out a clubbed, sticky tongue as long as the body, not counting the tail. They have an eerie way of moving so slowly that one cannot see when they shift. There is a quaint in-

dependent focussing of the eyes, which protrude in a strange way; and the focusing is so deliberate that one can hardly believe that the chamæleon will not lose the chance of the resting fly. First it focuses the right eye, and then it focuses the left eye; and when both are adjusted out comes the tongue. It takes a long time to get the sights right, but after that the discharge of the tongue is almost explosive. Perhaps "catapult-like" would describe it better. In any case it is usually a bolt from the blue for the fly.

We have said that the word chamæleon means "ground-lion," and it is a very quaint name. Not only does it tax the imagination to find a resemblance between a chamæleon and a lion, but most of the species live not on the ground but on the branches. Why should the curious creatures be called "lion"? Can it be because they strike terror in some eyes—a dog's, for instance? When they are attacked they occasionally make themselves *smaller*, but at other times they inflate their body and seem to threaten with their gaping mouth. Sometimes they hiss and sway angrily from side to side. Is there in this exaggeration of size, due to the expansion of lungs and air-sacs, some hint of the cat's similar bluffing of the dog? And is not the king of cats the lion, hence chamæleon? But it is dangerous for ordinary people to discuss etymologies, so we do not press our suggestion that the inflated indignant chamæleon is, through the analogy of the transformed cat, a "ground-lion."

We are on safer ground when we ask how the chamæleon is suited for life among the branches! Its prehensile tail is like a far-off hint of the monkey's, and the hands and feet are split so that they embrace the support. It is interesting to notice that the hand is divided into three fingers to the inside and two to the outside, whereas the foot is split with two to the inside and three to the outside! The Common Chamæleon may show half a dozen colours in the twenty-four hours. At night it is usually cream-coloured with yellow patches; during the day it is habitually grey-green, with numerous dark specks and some pale-brown patches; when excited it shows maroon-brown

patches and golden yellow spots; or, if it is very angry, the yellow spots become blackish-green. But this by no means exhausts the colour-repertory.

The colour-change is partly an expression of the creature's moods and partly an answer back to outside change; sometimes it increases conspicuousness, as if in warning; but sometimes it serves as a self-effacing cloak of invisibility. Just as the animal sometimes makes itself larger and sometimes smaller or slimmer, so in the colour-changes there seem to be two kinds of tactics—bluffing on the one hand and self-effacement on the other. The change of colour is brought about by the contraction or expansion of branched pigment-cells which lie in the under-skin or dermis, but the effect is complicated by the presence of numerous cells with yellow oil-drops and with guanin crystals or other strongly refractive particles. Speaking of the chamæleon's skin makes one think of the often repeated moulting, when the outermost layer of the outer skin (epidermis) dies away and rises up in blisters like pieces of tissue paper. The chamæleon gets rid of these in flakes by rubbing its body gently against stones and twigs.

The chamæleon is a bundle of unique peculiarities. When an ordinary lizard loses its tail at the hands of an enemy, it usually grows a new one, sometimes a bit of a makeshift. But the chamæleon's tail is not brittle, and it cannot be re-grown if removed. These two associated peculiarities may be understood when we think of the prehensile function of the chamæleon's tail, for if it is to support the animal it must be tough, and if it is coiled round the branch it is not exposed to danger.

Instead of scales on the skin there are granules; the eyelids are united so as to leave a pin-hole aperture; the tongue is kept like a spring in a tube, and its forceful propulsion is helped by an inrush of blood; the large lungs are continued into long narrow air-sacs—these are some other peculiarities of chamæleons.

Most of the chamæleons lay eggs in the ground, and the white miniatures are hatched out after a prolonged development. The mother usually broods. In a few cases, like

the Dwarf Chamæleon of South Africa, the young ones are hatched inside the mother, illustrating a step that many different animals have taken in the course of evolution, the step towards viviparous birth.

Very little is known of the intimate life of chamæleons, partly because they are elusive creatures and partly because they do not readily survive removal from their native haunts. It is not that they die quickly; they go on hunger-strike for months; but the end is almost always the same. They are almost rigidly insect-eaters, but they have capricious appetites. They require plenty of water. They sleep on the branches, securely fastened on. They circumvent extremes of temperature by taking refuge in the ground, but very little is known of this "lying low." We must think of them as transformed terrestrial lizards, for the most part remarkably well suited for arboreal life, which return to the old haunts when the season is too severe, or when they are about to start a new generation.

THE FRESHWATER LIZARD

Among freshwater animals it is strange that we have to include a lung-breathing lizard. But unexpectedness is one of the charms of Natural History. As Goethe said, animals are continually attempting the next-to-impossible and achieving it! Partly, no doubt, the struggle for existence supplies the spur; but in higher animals there is also the prompting of the spirit of adventure. Animals are always on the look-out for a new niche of opportunity, and thus we find the unexpected often happening. What is a lung-breathing snake doing in the sea a hundred miles from land? What is such a terrestrial animal as a spider doing in a pool on the moorland where she weaves a sub-aquatic dome of silk and fills it with dry air? How comes an Amphibian like the blindworm, or a bird like the burrowing parrot, to be living beneath the ground? Or, to come to our present point, what is a lizard doing in the water?

Reptiles were the first backboned animals to become quite at home on dry land, thus completing the great

transition which was begun by their amphibian ancestors. But not a few of them have in the course of time retraced their steps and gone back to the water, lung-breathers though they be. Thus there are crocodilians, turtles, and sea-snakes that we may call "secondarily aquatic." In the lizard order of reptiles, however, the terrestrial habit, including burrowing and tree-climbing, is so strong that exceptions are of great interest; and we wish to refer to the story that Dr. Ph. F. Kopstein has recently told of the "water-lizard" of the Moluccas. It is not a new animal by any means, but little has been previously known of its habits, which are certainly peculiar. Its name is Lophura, and the best known kind or species, living in Amboina, Ceram, and Celebes, is *Lophura amboinensis*, which Dr. Kopstein has studied. There is another kind in Ternate and Halmahera, and a third is at home in the Philippines. This suggests the rôle of isolation in fixing new departures into new species, as we know nearer home in the Orkney vole and the St. Kilda wren. In mankind, likewise, some form of isolation, narrowing the range of marriage, seems to have been a frequent factor in fixing racial traits.

The water-lizard or "hydrosaur" of Amboina never goes far from the water; it stretches itself on branches overhanging streams, ponds and lagoons, and dives if violently disturbed. The same individual comes back to the same branch day after day and lies there almost imperturbable. For it has no enemies—not even man. Apart from two kinds of civet, there are no beasts of prey in the Moluccas, and the natives do not eat the water-lizard. This explains the imperturbability of the adults.

It is very different with the young ones, however, for they are quick to hide themselves under stones in the bed of the stream or among thick vegetation in the pool. The reason is plain; they are persecuted by herons and hawks until they reach their adult strength, when all their shyness disappears. No wonder, for they are over two feet long! As for their own food, it consists exclusively of the leaves and other parts of plants growing in, or beside, the water. Dr. Kopstein found a number frequenting a pool in which

there were several warm sulphur springs, but he never saw one in the sea. So it remains true that the only marine lizard is the seaweed-eating Amblyrhynchus of the Galapagos Islands.

The eggs are buried eight to twelve inches deep in the fine river-sand at well-warmed spots where there is some stability. For just as our hen-salmon avoid depositing their eggs among shifting gravel, so the hen-hydrosaurs avoid shifting sand. Although the natives do not eat the adults, they are fond of the eggs, which have relatively large yolks and are said to be very palatable. They are worth searching for, since they reach a length of over two inches. They are enclosed in firm parchment-like " shells," dirty white, with grey spots and streaks. An interesting point is that hatching goes on all the year round, which puzzles us till we remember that the Moluccas have a climate almost without seasons.

Apart from habits, the most striking feature of the water-lizard is the tail-crest of the mature male. It rises like a sail along the dorsal middle line of the caudal region and gives the creature a very striking appearance. There is no doubt that it is a masculine exuberance, like the growth of antlers in a stag; and a notable fact is that it does not appear till the male is full-grown and lusty. A male two feet long is exactly like the female, but after that it unfurls its sail, probably with the help of a chemical messenger or " hormone " carried through the body by the blood. It seems very appropriate that a lizard that has taken to the water should have developed a sail; but this is only a coincidence, as is shown by its restriction to one sex.

THE SEA-LIZARD

One of the most remarkable reptiles is the seaweed-eating lizard (*Amblyrhynchus cristatus*), which frequents the rocky shores of the Galapagos Islands, and has acquired the habit of diving down among the seaweed for the kinds it likes best. It attains a length of four feet, and is sluggish on land. On the voyage of the *Beagle*, Darwin was much interested in

this animal, and noticed some very interesting features. "When in the water this lizard swims with perfect ease and quickness by a serpentine movement of its body and flattened tail, the legs being motionless and closely collapsed on its sides. A seaman on board sank one, with a heavy weight attached, thinking thus to kill it directly; but when, an hour afterwards, he drew up the line, it was quite active. Their limbs and strong claws are admirably adapted for crawling over the rugged crags and fissures of lava, which everywhere form the coast. In such situations, a group of six or seven of these hideous reptiles may oftentimes be seen on the black rocks, a few feet above the surf, basking in the sun with outstretched legs."

One of the peculiarities Darwin noticed is puzzling. The lizard is, of course, a lung-breather, and when it dives it must depend on the store of oxygen in its lungs and blood. Yet it takes to the water voluntarily and habitually. But it will not be chivvied into doing so. What puzzled Darwin was that when the lizards were driven on to a little point overhanging the sea, they would sooner allow a person to catch hold of their tails than jump into the water. When he threw one in, it returned at once. "I several times caught this same lizard by driving it down to a point, and though possessed of such perfect powers of diving and swimming, nothing would induce it to enter the water; and as often as I threw it in it returned." Darwin's explanation of this curious behaviour was that the lizard has no enemies on land, whereas there are numerous hungry sharks in the sea. "Hence, probably, urged by a fixed and hereditary instinct that the shore is its place of safety, whatever the emergency may be, it there takes refuge." It must be remembered that the lizard's marine excursions are probably of comparatively recent origin. In support of this view there is an interesting piece of evidence, namely, that the marine lizard has a "double," a near relative, that keeps to the land.

We must describe this terrestrial cousin a little, for though it takes us away from the seaweed, it lets us into a secret. Darwin called it just a kind of Amblyrhynchus; its technical



Photo: Reproduced from "Galapagos: World's End," William Beebe, by courtesy of the publishers, Messrs. G. P. Putnam's Sons.

FEMALE TROPIDURUS LIZARD.

Here the female is standing high and just about to begin her energetic bowing. "The males were grey and brown above, mottled and banded with black, with the underparts a mixture of pink, red, and contrasting black. The females were usually more of a monochrome brown, with a brilliant slash of fiery scarlet over face, shoulders and sides." This illustrates "sex dimorphism."

name nowadays is *Conolophus subcristatus*; but every one is agreed that it is nearly related to the marine form, and that it represents the old-fashioned way of living. When Darwin visited James Island, one of the Galapagos group, there were such crowds of these lizards that "we could not for some time find a spot free from their burrows on which to pitch our single tent." They are sluggish animals, that crawl slowly along with their tails and bellies dragging on the ground. They often stop and doze for a minute or two. In making the burrow in the soft volcanic earth one of these quaint lizards works first the legs on one side of its body and then those on the other side, in regular alternation. Darwin writes: "I watched one for a long time, till half its body was buried; I then walked up and pulled it by the tail; at this it was greatly astonished, and soon shuffled up to see what was the matter; and then stared me in the face, as much as to say 'What made you pull my tail?'"

The land kind differs from the sea kind in having the tail rounded, not flattened, and in not having webbed toes. It feeds on succulent cactus, on the leaves of acacia bushes, and on acid berries that fall from trees. But the most interesting point is just this, that of two near relatives, living in a confined part of the world, one has become a burrower and a cactus-eater and the other a swimmer and a seaweed-eater. The meaning of it all is that the conditions of life are difficult for them both, and were difficult for the common ancestors from which both are descended. Two very different solutions have been found, and one of these solutions was unique. For there is only one lizard that dives into the sea and swims about, and there is only one lizard that eats seaweed. The secret is this, that when animals are hard pressed they look about eagerly for any vacant corner or for any way of life that is not being tried. The realm of life is crowded with "shifts for a living."

TORTOISES

Keeping the name "turtle" for the paddle-limbed Chelonians of the sea, such as the sources of turtle soup and

of tortoiseshell combs, we may conveniently use the word "tortoise" for those that live on land, and "terrapin" for those that frequent freshwater. The kind oftenest kept in Britain is the Greek Tortoise (*Testudo græca*); the one Gilbert White studied was *Testudo ibera*, a nearly allied species. These Testudos are warmth-loving reptiles, fond of basking in the sunshine when it is not oppressively hot. They rise late and go to bed early; thus Gilbert White's pet used to retire at 4 p.m. in the long summer day and did not stir till late in the morning. It also buried itself in mould in November and remained in retreat till the middle of April—certainly the best thing for it to do in Great Britain. They do not sink into true "winter sleep" or hibernation, for that peculiar state is restricted to certain mammals; the reptile's condition is more like cold-coma or lethargy.

Gilbert White tells of the aged tortoise, which he eventually acquired, that "as soon as the good old lady comes in sight who has waited on it for more than thirty years, it hobbles towards its benefactress with awkward alacrity." He comments on the fact that this "most abject of reptiles and torpid of beings distinguishes the hand that feeds it and is touched with the feelings of gratitude." But even when we allow a good deal for the handicap imposed on the tortoise by the prevalent low temperature in a country like Britain—a foreign country to tortoises—it cannot be called a responsive pet!

In spite of the asseverations of vendors, who declare that the tortoise will speedily clear off the "black beetles," the animal is a vegetarian. Though it may learn to take bread and milk and the like, it prefers lettuce and cabbage, dandelions and clover. Dr. Gadow watched hundreds very carefully in the course of years, and he never saw one of them eating slugs or earthworms, though this is often asserted. The Gopher tortoise, that burrows in sandy pine forests in the South-Eastern States of North America, eats not only grass and succulent herbs but the resin of the pine trees, which must be strong spice. On the whole, it may be said with confidence that Testudos are vegetarians of the stricter sort.

Tortoises seem to have adopted a "ca' canny" rule of life; they do everything with extreme deliberation. They feed slowly and they grow slowly—we can tell their age up to an uncertain limit by counting the concentric lines on the horny epidermic scales, for each ring means a summer's growth. Gilbert White noted that his tortoise (now enshrined in the British Museum) became lively in the month of June and indulged in energetic "amorous rambles"; but in the ordinary tenor of its life the tortoise takes good care to avoid all over-exertion.

Many travelling naturalists have asked why so many islands have kinds of animals peculiar to them—kinds that do not occur anywhere else. Each island in the East Indies has its peculiarities in the way of monkeys, reptiles, fresh-water fishes, and snails. Each island in Hawaii has its own species of Honey-sucker, and each forest its own land-snail. Each of the three groups of rookeries in the Behring Sea has its own species of fur-seal. There is a kind of wren peculiar to St. Kilda and a kind of vole peculiar to Orkney. Why should this be?

In general terms the answer is as follows: Most living creatures are variable. Offspring are often different from their parents, and the members of a family are often very unlike. In other words, new departures are of frequent occurrence, and it is easier for a new departure to establish itself on an island than in a district where there are no restrictions to crossing. When a breeder finds new departures that please him with their promise, he tries to pair them with others like themselves, or as like themselves as possible. In other words he brings about inbreeding in order to establish a new race. This inbreeding tends to occur in Nature when there is anything that restricts the range of crossing, and that is easier on an island than on the mainland.

When Darwin visited the Galapagos he was greatly interested in the giant tortoises, perhaps most of all in the fact that different, though nearly related, forms occur on different islands. As he said, he was "brought near to the very act of creation." He timed one large fellow, and found that he walked at the rate of sixty yards in ten

minutes, which is about four miles a day. Yet they cover considerable distances when they have a thirst which neither the succulent cactus, nor the green threads of pendulous lichen, nor the guayavita berries can slake. "Near the springs it was a curious spectacle to behold many of these huge creatures, one set eagerly travelling onwards with outstretched necks, and another set returning, after having drunk their fill." Darwin noted that the old ones "seem generally to die from accidents, as from falling down precipices; at least several of the inhabitants told me that they never found one dead without some evident cause." In other words, the giants live so long that they do not die a natural death. Yet the pathetic fact is that they will soon be exterminated. Every naturalist who has visited the islands has noticed, and perhaps deplored, the dwindling number of tortoises, and has then left the islands poorer.

The giant tortoises frequent the valleys where there are water-pools and succulent plants, but they climb the mountains in summer. The rocks on their favourite routes have become in some places so much smoothed that it is almost impossible to walk on them after a shower. Except in the midday heat and glare the tortoises may be seen or heard prowling about in their leisurely way, whether it is dark or light. In 1905 a visitor counted over thirty in three miles. It seems that the roving is in great part amorous, and the males utter barking cries which can be heard for three hundred yards in the forest. This seems to contradict the belief, to which Darwin refers, that the giants are absolutely deaf.

The eggs, larger than a hen's, are laid in layers in holes in the ground, and there may be eighteen or so in one nest. But the mother tortoise does not put all her eggs into one basket. There seems to be great juvenile mortality, the chief enemies of the young tortoises being buzzards and wild dogs. After they are a foot long they are more or less secure except from man, whose impious ruthlessness is often fatal. The flesh is unfortunately palatable, and the oil yielded by the fat used to command a good price. Scientific

collecting is also to blame. So it has come about that some of the islands have only a few tortoises left, and in other cases there are none. In no case can we blink the discreditable fact that the days of the multi-centenarians are numbered.

Our regret over their passing is not because the giant tortoises are antiques like the "living fossil" that goes by the name of the New Zealand Lizard or Sphenodon—the sole survivor of a very ancient reptilian race. The point about the Galapagos tortoises is that they afford or afforded such a fine object-lesson in species-making. Almost every island had, not so very long ago, its own species, to the number of fifteen altogether. Only on Albemarle Island is there more than one race. There seems no interpretation possible except the Darwinian one that all the species are derivatives of one, which inhabited a single large island—now represented by the archipelago. When the island by submergence gave rise to the present discontinuous peaks, groups of similar tortoises were isolated, and variations in these inbreeding groups gave rise to the fifteen differentiated species. If it should seem more convenient to call them varieties, not species, it makes no difference to the general argument and lesson. As land tortoises soon drown in the sea, it is necessary to account for their presence on the original island, and the most plausible hypothesis is that there used to be a great land-bridge establishing a connection with Central America. It may be recalled that the Galapagos Islands lie on the Equator some 500 miles west of South America and 660 miles south of Costa Rica.

Giant tortoises may live over 150 years, and for some individuals, as we have mentioned, several centuries have been claimed. Yet there will soon be none of them! Dampier and other old travellers saw hosts; Mr. Beebe saw one! And it soon died after proving that it could swim for a while in the sea—affording material for hundreds of feet of moving picture film. Man is not a good trustee.

It is congruent with the slow life of tortoises that many of them should live to a great age. They are slow in ageing, slow in dying! Gilbert White's tortoise survived its

master about a year, dying in 1794, after an existence in England of about fifty-four years, the last fourteen of which were spent at Selborne. A few centenarians have been known. In 1766 five giant tortoises were brought from the Seychelles to Mauritius, and one of these was living at the beginning of this century. In 1901 Dr. Gadow reported that "though nearly blind it was otherwise of regular habits and in good health." Its shell length was over a yard, and it could carry two men on its back.

Slow in so many respects, tortoises are not quick in the uptake. The brain is almost ridiculously small compared with the size of the skull. But we suppose they are as clever as they need to be, else they would not have lasted so long. They learn to discriminate between people, and they have a distinct aptitude for geography. They master their region, and can return home from a considerable distance. They remember their particular winter quarters, even when it is in a rather out-of-the-way place. A terrapin has been known to solve the problem of a maze, which is at least evidence of profiting by experience. There is a well-authenticated case of common tortoises craning their necks to listen to the town band playing on the square adjoining their garden, but we do not know whether this could be cited as evidence of intelligence. Ordinary tortoises do not speak much, but they have their little "piping" at the breeding season, the miniature echo of the hoarse roar or bellow of the male Giant Tortoise of Chatham Island, which Darwin heard at a distance of more than a hundred yards. Common tortoises lay two to four white-shelled eggs, like those of pigeons, and bury them in the loose soil. We have never heard of any parental care.

The slow-going tenacious vitality of tortoises and their kin is expressed in the well-known "local life" of parts of their body. Thus the heart of the edible turtle, kept in appropriate surroundings, retains the power of beating for a week or more after the flesh of the animal has been made into soup. This is very remarkable, but we think the most remarkable thing about the tortoise is its armour. Gilbert White speaks of it somewhat dubiously—"Pitiable seems

the condition of this poor embarrassed reptile ; to be cased in a suit of ponderous armour, which he cannot lay aside ; to be imprisoned, as it were, within his own shell " ; but the other side of these intricate shields is that they confer invulnerability. Is any animal in Europe able to make anything of the Greek tortoise, except the Greek eagle, which lifts the creature in its talons to a great height and lets it fall on the rocks below. For all ordinary contingencies the tortoise is safe ; boxed in above, boxed in below, able to draw in its head and tail and limbs, with a shell built on the principle of an arch or tunnel, the tortoise is able to cultivate a masterly indifference to assault. Even more remarkable, however, is the extraordinarily intricate way in which elements of exoskeleton and endoskeleton are soldered and welded together into what is to the tortoise a growing and moving fortification and to us an anatomical puzzle. (1) On the outside above and below there are the horny, epidermic scales. (2) In the middle line of the dorsal carapace there is a row of bones made out of the flattened tips (neural spines) of the vertebræ. (3) Outside these there is a row of under-skin bones—dermal scutes—which are plastered on to the neural spines. (4) The sides of the dorsal carapace are made of the flattened-out, rigidly fixed ribs. (5) Outside these more scutes are plastered on—the costals. (6) The ventral shield, or plastron, consists of bony plates—badly called " abdominal ribs "—which ossify underneath the skin of the abdomen. (7) But the front part of this ventral shield is believed by some authorities to represent the collar-bone. There is no breast-bone. What intricacy of " make-up " !

THE CROCODILE

In Western Africa, wherever the forest is broken by the course of a river, or the rain-forest gives place to jungle and swamp, the great aquatic reptiles, the crocodiles, are found. The crocodile is stiff and awkward on land, finding it difficult to turn round quickly, so it takes to the water when it is alarmed, and it does its hunting from the water, too. But

it likes to lie on a warm sand-bank at the edge of the river, basking in the sun for hours during the hottest part of the day. Dozens of them will sometimes lie quite close together along a stretch of sand, attended by a crowd of plover-like birds, which hop about the monsters fearlessly, picking leeches from their armoured backs.

The crocodile crawls down the bank on its short legs and disappears under the water. For a long time it lies there motionless, with only the tip of its snout showing, but it is not dozing now, it is watching for its prey. A little antelope slips out from the edge of the jungle and stands at the brink in its curious "whipped dog" attitude. It does not see the nostril-bearing snout of the crocodile, which might be just a stone or a lump of mud, so it stoops to drink. Noiselessly the crocodile swims nearer, then with a sudden rush and a lashing of its mighty tail it is upon the antelope, and has caught it fast in its powerful jaws. The crocodile usually drowns its prey, and it is able to hold the animal under water without drowning itself, because it can close its nostrils both externally and at the posterior opening far back in the mouth. The entrance to the windpipe is shunted forwards against the posterior nostrils, and if the anterior nostrils are then opened and raised above the surface, breathing can go on undisturbed by the water in the mouth. Cattle, sheep, and all kinds of wild animals and birds and fish become the crocodile's victims, and even human beings are sometimes attacked when they come to the river to draw water.

The crocodile comes on land for another reason besides basking in the sun, for it makes its nest in a hole in the sand. The mother scoops out a fairly deep hole and there lays her large white-shelled eggs which are like those of a goose. She covers them over with the warm sand, and spends a good deal of time on guard, using the spot as her basking-place. In about three months' time the young ones break through the shells, chipping them open with a special "egg-tooth" and make curious little sounds, which have been compared to a hiccough, till the mother comes and helps them to struggle out of the sand. She is more affectionate than

most reptile mothers, and she proudly leads her family to the water.

It is interesting to note how often the big animals of the swamps have their attendant birds. The crocodile-birds are useful to it in ridding it of troublesome parasites, while the bird profits by a constant supply of food. The red buffalo, which is a splendid swimmer, is often accompanied by a flock of buff-backed egrets and other birds, which follow it through the swamps in order to catch the insects disturbed by the buffalo's hoofs. Sometimes these bird companions are useful to the buffalo in drawing attention to some approaching danger. It is quite certain that the rhinoceros depends a good deal on its "sentries," the little tick-birds that fly about with it and settle on its back to seek the ticks on its hide. If the birds fly up suddenly the rhino at once becomes alarmed, while their return and placid settling down to feed again have a soothing effect on the big beast.

There is such great diversity within the class or group of Reptiles that we have not been able to do more than give some glimpses of their ways; but we have chosen these so that they are *characteristic*.

XIX

THE WAYS OF AMPHIBIANS

ONE of the services that Huxley rendered to the science of Zoology was to show convincingly that Amphibians, such as frogs and newts, are more nearly related to Fishes than to Reptiles. Thus almost all Amphibians breathe by means of gills when they are young, and some retain these fish-like breathing organs throughout their life, even when they acquire lungs, suited for breathing dry air. But a young Reptile never has gills. No doubt Amphibians have risen high above Fishes in many ways, as in the possession of fingers and toes, true lungs like our own, and a movable tongue ; but there is no denying their many fish-like features. So in spite of appearances, Amphibians must be linked back to Fishes, and Birds back to Reptiles.

In the ages when the coal-measures were formed there were some giant Amphibians, but those of to-day are mostly small. They include: (1) the newts and salamanders with a well-developed tail; (2) the frogs and toads which lose their tail at the end of the tadpole stage ; and (3) the strange, earthworm-like, burrowing, limbless blind-worms or Cæcilians.

AMPHIBIAN BEHAVIOUR

Some animals, such as pigs, are much cleverer than they look, but many other animals look much cleverer than they are. Frogs and toads belong to the second group. When we watch a toad climbing up a bank by the roadside, we get a suggestion of a shrewd old man. When we watch a frog focusing a fly we get an impression of intense concentration. The creature looks as if it were " intending its mind thereunto," to use Sir Isaac Newton's famous phrase. But there

is good reason to suspect that the suggestion and the impression are both too generous. Perhaps we are misled by the relatively large head, forgetting the almost ludicrously small brain inside. There is something in the eye, especially the toad's, that inclines us to be generous. Miss Frances Pitt, in her delightful *Wild Creatures of Garden and Hedgerow*, speaks well of the toad's " gleaming jewel-like eyes. They are a pale metallic brown with reddish lights like flickering fires in their depths."

Frogs and toads can learn to distinguish between different people, but we do not know how. They can find their way " home " from a distance of two hundred to three hundred yards. But the most satisfactory observations are those made by Professor Asa Schaeffer on various kinds of American frogs. He found that frogs learned after a few trials to avoid disagreeable objects, such as hairy caterpillars, and that the lesson was remembered for at least ten days. Another frog learned in two trials not to have anything to do with earthworms that had been dipped in some drug. The lesson was perfectly remembered for a short time, and somewhat imperfectly for five days. When a frog got a mild electric shock on seizing an earthworm it declined earthworm for a whole week, but it did not decline mealworm. We see, then, that *frogs can learn*, and it is plain that a few observations made with great care are of much more value than a multitude of anecdotes that will not bear scrutiny.

Some of the details of Professor Schaeffer's experiments are of unusual interest. When the frog seized the hairy caterpillar, it at once rejected it violently from its mouth. It had this experience to stamp in the fact that the caterpillar was very undesirable. On the other hand, the chemically treated caterpillar was actually eaten ; there was no muscular rejection ; but there must have been indigestion, for the frog remembered. The lesson, " No more earthworm for me," lasted for some time, but for a much shorter time than in the case of the hairy caterpillars.

Now it is very important for frogs and other Amphibians in their everyday life to learn rapidly to avoid disagreeable foods. It saves time and energy and pain. What we may

safely say is this, that a frog begins by testing many things, but *learns* after some experiences to avoid those that are undesirable. This is quite different from obeying an inborn feeding instinct that never makes mistakes. It is not difficult to understand why the frog that is fairly quick to learn about food, is very slow to learn how to get out of a maze, or even how to circumvent a transparent thread—by hopping over it. For these are difficulties which it does not need to face in its ordinary daily life.

Let us linger a little in Professor Schaeffer's laboratory. By a simple device it was arranged that when a frog made a rapid mouthful of a cockroach it got a mild electric shock. This stopped the eating of cockroaches, but it also stopped all eating for some days. The surprise put the frog off its food altogether. There was not much *learning* here.

In the case of the hairy caterpillars that we referred to, there was a rapid linking together of the sight of the caterpillar and " not having any " ; and the lesson lasted. Here there was the beginning of the habit of not eating hairy caterpillars !

But there was another experiment that takes us a little further, and gives us, we think, a glimpse of the frog's mind at work. A hairy caterpillar was dropped in front of an experienced frog and began to crawl away. But a frog likes things that move, it will not eat dead things, so it hopped after the hairy caterpillar and closely examined it as it crawled. The frog was interested, but it refrained from further action. The movement of the caterpillar had pulled the trigger of the frog's interest, leading it to hop ; but closer inspection awakened an old prejudice—perhaps a memory of a previous disagreeable experience. But when the frog carefully scrutinised the hairy caterpillar which it had followed was it not " making up its mind " ? In any case it said to itself, " No."

But the story does not end here. The hairy caterpillar, in which the frog had lost interest, tumbled into a dish of water and wriggled energetically on the surface. This novel wriggling once more arrested the frog's attention, and a re-investigation took place. But ten seconds sufficed to



Photo : Ellison Hawks.

COMMON SMOOTH NEWT (*Triton vulgaris*).

This common newt is about three inches long, olive-green to brown above, yellow and orange below. At the breeding season the male has a wavy crest, but it is not serrated as in the crested newt. There is also a blue stripe on the tail.

assure the frog that it was the same old hairy caterpillar ; and it finally turned away. We do not say that there was much of a mind here, as men count mind, but surely there was a glimmering.

It is interesting to contrast the ways of the toad with those of the frog. The toad is leisurely and dignified ; the frog is quick and nervous. The toad crawls, the frog hops. This may be due to a deep down difference in constitution or temperament, but we wonder whether it may not have something to do with the fact that the toad's life is much safer than the frog's, because of its much more abundant poison. The toad cannot spit poison, but its skin manufactures an irritant and unpalatable poison called " phrynin," and although there is something approaching this in the frog it is small in amount. There are very few animals that will take a toad in their mouth, and the leisureliness of the toad may have something to do with this. Perhaps the toad has a sense of security.

We have referred to some experiments on Amphibians, but what of these animals as experimenters on their own account ? Let us think of their history and of the acquisitions they made. The race of Amphibians, represented nowadays by frogs and toads, newts and salamanders, and by the strange earthworm-like Cæcilians, emerged towards the end of the Old Red Sandstone Age, and we think that there must have been considerable adventurousness and inventiveness in the original Amphibian temperament ; they made so many new steps of great importance. They were experimental.

Derived from a fish-stock, such as is indicated to-day by the Mudfishes or " double-breathers " (Dipnoi), which have turned their swim-bladder into a lung and are able to breathe dry air for half the year, the Amphibians made the great step of leaving the water and getting on to dry land. Some backboneless animals had already taken this dangerous, though promiseful step ; but Amphibians were the first backboned animals to live on land. And it must be remembered that only a few of them, like some of the tree-toads and the Black Salamander (*Salamandra atra*), that lives above the

snow line on the Alps, have quite emancipated themselves from the water. In all ordinary Amphibians the youthful stages, such as the familiar tadpoles of frogs and toads, must be cradled in the water. They die if the pools dry up.

It is a general rule in the animal kingdom that if a race has changed from one habitat to another, the members tend to go back to the old kind of haunt when they are about to start a new generation. Thus the fish-eating turtles, like the Loggerhead, come from the open sea to lay their eggs on the sandy beach ; and the robber-crabs come from their inland haunts to lay their eggs in the shore waters. For Amphibians this rule of life holds particularly true. We see the toads at the breeding season walking a considerable distance to a suitable pond. The juvenile stages are for some time very fish-like—in their mode of respiration by gills, in their two-chambered heart, in their non-mobile tongue, in their lateral line of sensory cells, and so on. There is a great deal of the fish still lurking in the tadpole. During the first three months of its life, the frog has to climb up its own genealogical tree, but eventually it achieves individually what the Amphibians achieved as a race—the transition from water to dry land.

One is not forgetting, of course, that some Amphibians, like newts and axolotls, are much less terrestrial than others ; but all normal forms develop lungs and are able to breathe dry air. If the shores of the North American lake are uninviting, the axolotls may remain all their life in the water and retain their gills—just as children with an imperfect constitution sometimes remain for years like infants. But if the shores are attractive, the axolotls get on to the land, lose their gills, and change their shape not a little. The axolotls become Amblystomes, which were for a long time regarded as different species. To put it in another way, the axolotls are permanently larval forms, which do not quite attain to the adult characters of the Amblystome, though they are able to breed. But the large fact is that, among backboned animals, the adventurous colonisation of the dry land is to the credit of the ancestors of our Amphibians. No doubt there may have been long periods of drought during which water-basins

dried up, giving their tenants the alternative—to explore or die; no doubt there may have been overcrowding in the pools; but something, we think, should be allowed for the deep tendency that there is in living creatures to test all things and hold fast that which proves to be good.

GAINS MADE BY AMPHIBIANS

Another great step taken by pioneer Amphibians was the acquisition of fingers and toes. In fishes, which came before Amphibians, there were two pairs of limbs, but they were not more than fins. That is to say, they were without digits. The gaining of digits by Amphibians meant much: it meant some power of grasping—a support or a mate; some power of tucking food into the mouth; and some power of feeling things in three dimensions. We get a glimpse of the days of small things when we look at the weak limbs of most newts, hardly able to lift the body, slowly levering the creatures along the mud or paddling gently in the water. The important swimming organ in these animals is the tail, just as in fishes; or, more accurately, it is the muscular posterior region of the body, which displaces masses of water to either side alternately. In a few cases, it is interesting to notice, the amphibian hand is used for digging.

In most cases the hard parts of animals are the only parts that are preserved in fossil form, so that we cannot say much about the tongue in the ancient extinct Amphibians. But we know that Amphibians sooner or later gained a movable tongue, and they are the first animals to be able to shoot out the tongue. Many a fish has a tongue, but it is a *non-muscular* mass (connective tissue covered by mucous membrane), and it cannot be moved as such. It cannot move except along with the whole floor of the mouth. But the frog moves its tongue to good purpose, shooting it out on the unsuspecting insect, and taking very good aim.

The frog's tongue is very different from ours. It is fixed to the very front of the lower jaw, and is loose behind and broadly bilobed. When it is shot out, downside up, it can reach to a considerable distance, and its moist surface helps

to secure the insects. Now it is very interesting to find that the young tadpole cannot move its tongue. It has muscle-fibres in it, but they have to develop for a while before they are strong enough to move the tongue as a whole. Here again it seems as if the frog was slowly climbing up its own genealogical tree.

We cannot tell what vocal powers were possessed by the pioneer Amphibians, which had their Golden Age in the Carboniferous times, when most of the coal-measures were laid down. But we know that the Amphibians were the first vertebrate animals to have a voice. As in ourselves, the sounds made by the male frogs when they are serenading their mates, are due to the rapid passage of out-breathed air over the vocal chords stretched taut in the larynx. The first significance of the voice was as a call from male to female, and so it remains in Amphibians. One cannot think too often of the natural history of the voice, how it broadened out from being a sex-call to be a maternal call, a filial cry, a kin-signal, a warning of danger, a way of conveying tidings and expressing emotion, and, at last, a medium of reasonable discourse. The carrying power of the Amphibian voice has been estimated at three-quarters of a mile for an American bull-frog. It is often increased in the males by the development of a pair of resonating sacs (badly called "croaking" sacs), which sometimes protrude like soap-bubbles from the mouth. They are delicate paired expansions of a special muscle of the throat region, and are inflated when the frog is croaking. They are well seen in the males of the Common Edible Frog (*Rana esculenta*) of the Continent. In many cases they are present without protruding. In the common tree-frog the two unite to form a median pocket which can be inflated so as to equal in size the whole of the rest of the body—a very extraordinary state of affairs.

We have ventured to speak of Amphibians as having an *experimental constitution*, and we get a glimpse of this in the case of Darwin's frog (*Rhinoderma darwini*), a small South American species in which the resonating sacs are used by the male for sheltering the eggs and larvæ. There are five

to fifteen eggs ; and as many as thirteen young ones have been found in the two resonating sacs. These become so large that they spread over the whole ventral surface of the father-frog. Eventually the young frogs clamber out of their father's mouth. This is certainly one of the strangest of cradles !

But the resonating sacs may have another use, which is also quaint. In two kinds called Paludicola (which means marsh-dweller) and Breviceps (which means short-head), the resonating sacs can be inflated very suddenly, and this is believed to have a " terrifying " effect on enemies. The armourless and weaponless Amphibians need all the help they can give themselves. The ancient Amphibian giants, called Labyrinthodonts because their teeth had an intricate labyrinth-like internal pattern, had armour, and there are minute scales embedded in the skin of the burrowing Cæcilians, which are the most old-fashioned of present-day Amphibians. But apart from the Cæcilians and two or three exceptional cases, the modern Amphibians are marked by their *nakedness*. Thus we can understand the value of a poisonous unpalatable skin, or of an arboreal habit, or of being green in green surroundings, or even of such a quaint peculiarity as blowing two balloons out of the mouth.

PARENTAL EXPERIMENTS

The usual Amphibian method of dealing with the eggs is seen in ordinary frogs and toads. The eggs are liberated in the water and float, helped by the swelling up of the transparent white-of-egg or albumen. In the case of the frog the " spawn " consists of buoyant masses of gelatinous spheres, each with a dark centre, about a tenth of an inch in diameter, which is the egg itself. In the toad there are two long glairy strings, which are twined among the water-weeds.

In the blind, limbless, burrowing Cæcilians, which look superficially like earthworms, the eggs are laid in damp earth, and the gills, which would not be of use underground, are shunted back into the embryo stage, before the egg-

envelope has been burst. This shows how the past lives on in the present, for the gills persist though they might well be dispensed with. The case of the Cingalese Cæcilian called Ichthyophis is very interesting, for the adult has become a thoroughly terrestrial animal—burrowing like an earthworm. It could not deposit its eggs in water; the fact is that it drowns if it is put into a pool. The mother lays a few eggs in damp earth, often near water, and she coils her body round about them, secreting slime from her skin which keeps them moist, and also, perhaps, nourishes them. When the larvæ are hatched out, they make for the nearest stream and sojourn there for a while—an interesting instance of a temporary return to the ancestral haunt of the Amphibian race.

If the Cæcilian blindworm coiled round its little bunch of eggs points the way to the brooding python, there are other Amphibians that anticipate the Marsupials in having a pouch for the eggs and young. Thus in the female Nototrema (which means back-pocket), a dorsal fold of skin forms a capacious backward-opening brood-sac in which the eggs develop. The larvæ may have long respiratory threads continued out from the gills, and in the tadpole of *Nototrema oviparum* there is a pair of beautiful long-stalked balloon-like bladders projecting from the breathing aperture. Each balloon has two blood-vessels, one coming to it with impure blood, and the other going from it with pure blood. This is one of the most extraordinary breathing arrangements in the animal kingdom, and it has to do with the fact that the young ones remain for a considerable time huddled together in the pocket. In this case the tadpoles change into little frogs within their mother's pocket; but in other Nototremas the tadpoles escape into the water.

On a different line, but not less interesting, is the case of one of the tree-toads called Phyllomedusa, where the eggs are laid in a nest made of leaves on a branch overhanging a pool. At the appropriate time the bottom of the nest gives way, launching the larvæ into the water. Nothing could be better!

Some tree-frogs carry their young ones on their back, or

even in their mouth. Dr. Christy describes a tree-frog's nest on the upper surface of a large leaf in the forest near a swamp: "The nest consists of a lump of white surface-dried froth or 'spittle,' about the size of one's fist, and discoloured on the outside. Broken open, it is seen to contain a number of small tadpoles moving about vigorously in the wet frothy interior. In this mass the eggs are hatched, and when the tadpoles are old enough to look after themselves they drop into the water beneath or live amongst the leaves and moist verdure of the swamp."

Very extraordinary is the experiment that has been made by the Surinam Toad (*Pipa americana*) found in Guiana and Brazil. At the breeding season the skin of the back of the female toad becomes honeycombed with small pits with a rich blood supply. As the female lays the eggs (forty to one hundred in number) she manages to get them on to her back, helped by the attentions of the male, who fertilises them. They sink into the skin-cradles, which are then closed with a firm coverlet. Development proceeds, and by and by the mother's back is covered with a crowd of little toads, which burst off the coverlet, squirm half out, and look round! There is a tadpole stage with external gills and with a long tail which probably helps in respiration; but the young ones do not leave their mother's back until they are fully formed miniature toads. They do not go near the water at all, so the Surinam Toad is an Amphibian that is ceasing to be amphibious.

Very different is the story of the Nurse-Toad (*Alytes obstetricans*), which is not uncommon in some parts of Europe. The male takes possession of the eggs just as they are laid by his mate, and after they have been fertilised he manages to entangle them round the lower part of his hind-legs, for the eggs are bound together by elastic threads. He sometimes goes the length of having two bunches of eggs to look after. All this happens on dry land, and the father-nurse remains there, except that on very dry evenings he sometimes has a bath, which will be all the better for the eggs. After about three weeks, however, he plunges into a pool, and the young ones, now at the stage of limbless

tadpoles, bite their way out of the jelly of the packet and are free. When he has got rid of all his family the nurse-frog returns to dry land. It is interesting that there should be among Amphibians so many instances of paternal rather than maternal care. It is a line of experiment that has not been much followed among higher animals, though one must not forget that many male birds share in the patient task of brooding.

Why should there be among Amphibians such a variety of devices for securing the safe development of the young? Part of the answer is that Amphibians are betwixt-and-between animals—one foot on land and one in water, so to speak. They were the first backboned animals to try with persistence the hazardous passage from water to dry land, and they were also, as we have mentioned, singularly destitute of armour and weapons. The problem of safely disposing of the eggs could not always be met by laying them in the water, as the Common Frog does. Other devices had to be tried, especially when the parents became more and more terrestrial. So one of them makes a leaf nest overhanging the pool and another digs a burrow in a moist bank; a mother may carry the eggs and young in a pocket on her back; a father may shelter them in an enlarged resonating sac. How are we to think of these experiments?

We cannot suppose that individual Amphibians sat down and pondered over the problem they had to face, for Amphibians have very poorly developed brains, and it is probable that Nature's way of working was more indirect. Changes or variations in behaviour are frequently arising, just like variations in structure; they well up from the fountain of changefulness that there is in the germ-cells when the individual life begins. These new departures or variations are tested by the individual in the course of its life, and those that are most successful become part of the hereditary ways of the race. To change the metaphor, a living creature often finds itself with a new "hand" of hereditary cards; it is for the individual to play this "hand" with all the mental ability it possesses, testing everything and holding fast that which is good. *What is certain* is that

Amphibians show a great variety of ways of solving the problem of giving the next generation a good send-off in life.

THE COMMON TOAD

As a type of the betwixt-and-between animals, recalling the time millions of years ago when backboned animals began to colonise the dry land, we take the toad, a literal Amphibian. It is a much misunderstood animal. No one likes to wear second-hand clothes, but how ready people are to garb themselves in second-hand opinions! One of these is suggested by Juliet's phrase, "the loathed toad." For this admirable amphibian undoubtedly suffers from a deeply rooted traditional prejudice, which disappears whenever one looks at the toad for oneself and with a fresh eye.

Even a good naturalist like Pennant of the eighteenth century wrote terrible nonsense about the toad: "The most deformed and hideous of all animals; the body broad, the back flat, and covered with a pimply dusky hide; the belly large, sagging and swelling out; the legs short, and its pace laboured and crawling; its retreat gloomy and filthy; in short, its general appearance is such as to strike one with disgust and horror."

One cannot expect every animal to be like a butterfly, and it is not claimed that a toad is as handsome as a squirrel. There is difficult beauty and easy beauty, and the toad's is a little difficult. But if we could get the verdict of an unpacked jury, including a few artists who are experts on beauty, it would be unhesitatingly in favour of the toad. It is a bit of a grotesque, of course, but it is an artistic unity.

The shape is compact and well-proportioned; the skin is wrinkled and warted, reminding one of the rugged, weather-beaten face of an old ploughman. The colours are pleasing. Dr. Gadow describes them as "olive grey to dark brown above; the under parts whitish, often with a brown, yellow, or reddish tinge." There are many colour-varieties, and even an individual can change considerably according to its moods and haunts. The eyes are undeniably fine, with a red or coppery iris: "Some say the lark and loathed toad

change eyes." The movements may be slow, but they are dignified, sometimes suggestive of a very old man. There may be short hops, but toads usually crawl. They are seen at their best when climbing up a steep bank, and some of their near relatives are arboreal. At the breeding time they swim strongly. The shooting out of the rosy tongue is a neat and effective trick, and we like, we must confess, to see a toad poking a gripped earthworm into its mouth with its fingers. In short, we do not find much that is ugly in a toad.

The toad is a self-effacing animal. It hides in holes by day; it hunts at dusk for insects, earthworms, and small snails. It lies in a lethargy through the winter, burying itself in loose, dry earth or in the midst of withered leaves, perhaps in the hollow stump of a tree. During its summer activity it moults the outermost layer of its skin every few weeks, contorting its body, scraping with fingers and toes, and gradually slipping out backwards from the transparent husk, which it then proceeds to swallow, rolled up into a pill.

The pairing takes place in early spring, often about the beginning of April, and there is frequently a longish journey to a suitable pool. The ardent males, who are far more numerous than the females, fight with one another for possession, and are very prolonged in their embrace. Dr. Boulenger compares their cry to "the distant barking of a little dog"; Dr. Gadow compares the female's weak response, which goes on day and night, to "the whining bleat of a lamb."

The eggs, which may number 2000–7000, are laid in two double strings, sometimes ten feet long; they are fertilised as they are laid; and they are entangled among water-plants by the movements of the coupled pair. In about a fortnight the tadpoles emerge, but nearly three months are required before the metamorphosis is completed and the miniature toads leave the water. They are not quite three-quarters of an inch in length, and more agile than their parents. They hide among grass and in little holes in the ground, and when a summer shower interrupts a time of drought they sometimes appear in such numbers

that credulous people insist that it must have "rained toads."

The Common Toad (*Bufo vulgaris*) may be distinguished from the Common Frog by its warty grey-brown skin, by having no teeth, by its less-developed web between the toes, by its much shorter hind-legs, by its crawling and climbing, by its nocturnal habits, by the laying of the eggs in strings, and in many other ways. One must remember, however, that there are toads and toads. Within the genus Bufo alone there are about a hundred different species, distributed all over the world except in the Australian region and Madagascar, and some of these are not like our Common Toad. Thus the African Jerboa Toad has very long and slender limbs. Moreover, there are some burrowing frogs that are very toad-like.

Thus, in the long run, to find the right answer to the question, "Why is a toad not a frog?" we should have to pry into technicalities which enter into the very bones.

The second British toad, the Natterjack (*Bufo calamita*), has large vocal sacs, a very loud croak, yellow eyes, and considerable brightness of colouring. Its hind-legs are so short that it cannot hop, but it can run at a fair speed. Unlike the Common Toad, it occurs in Ireland as well as in Great Britain.

The toad is said to be "a slimy creature, spitting venom," but it is rather dry-skinned and it cannot spit. It is said to suck the udders of cows, but it cannot suck, and it does not drink. Most of the popular beliefs about toads are clotted nonsense, and no one has ever verified the zoological part of the familiar lines:

> "Sweet are the uses of adversity,
> Which, like a toad, ugly and venomous,
> Wears yet a precious jewel in his head."

It is a pity that an inoffensive creature, likeable in many ways, timid and tamable, apparently able to recognise a friend, should have been libelled so basely.

It is always of interest to raise the question of survival, and the answer in the case of the toad must be found in its

quiet, elusive ways, its burrowing, its crepuscular activities, and its capacity for lying low without food in the winter. But it has another quality that is of survival-value, namely, the abundant secretion of poison from the skin-glands, especially from a large cluster behind the eye. What we see is a creamy fluid which oozes out when the animal is stoned. It includes an irritant volatile poison called phrynin; and as this makes the toad's skin very unpalatable, it is better than any armour.

THE STORY OF PROTEUS

One of the most famous of cave-dwellers is the "Olm" or Proteus, a newt of sorts, a dweller in darkness in the underground waters of Carinthia, Carniola, and Dalmatia. It is known from over forty localities, mostly caves with slow-flowing streams. When the streams are low, the olms are often found in stagnant pools with a muddy bottom, but their preference is for flowing water. When the streams are swollen, the olms are occasionally carried outside the cave into the light, which they do not seem to enjoy. One of the earliest records (1761) of Proteus was from the Lake of Zirknitz, into which it had been swept by a flood. But we must certainly think of the animal as a typical cave-dweller, a true troglodyte, not at home in the light. It is nocturnal all its life and all the twenty-four hours, and though it can wriggle on wet mud, it prefers to keep to the water. The temperature of its haunts is low and uniform, about fifty degrees Fahrenheit.

Picture a slender, blind, newt-like animal, towards a foot in length, with smooth, flesh-coloured skin. There are sometimes hints of spots, but the most marked touch of colour is where the red blood shines vividly through the three pairs of gills. These are usually branched or tufted. The head is elongated and obtuse in front, a little suggestive of a pike's. Proteus is very weak in the legs, which must be regarded as in process of degeneration. They are not strong enough nor long enough to support the body; the fore pair have only three fingers, the hind pair only two

toes. The swimming is effected by lateral undulations of the tail, which is flattened from side to side, in contrast to the cylindrical trunk of the body.

Museum specimens of Proteus look very white and wan, except at the gills, but it is of some importance, as we shall see, to notice that the living animals show considerable variability. There are hints of yellow, reddish, and even violet in the ground colour, and of yellow, grey, and reddish in the spots. This probably depends mainly on the surroundings, especially on the intensity of the darkness, for there is no doubt that even faint light induces colouring or pigmentation. Similarly, while we may fairly speak of the olm as blind, meaning that the eyes are degenerate and do not reach the surface, it is of interest to notice that they can sometimes be seen as darkish points shining through the skin, and that they are more marked in the young than in the adults.

Very little is known of the home life of Proteus, for a dark cave is not suitable for zoological observations. Indeed, the chief haunts are probably inaccessible, since no larvæ, or even youngsters, are ever found. Fortunately the animals are patient of captivity, and up to an uncertain limit we can argue from the known to the unknown. Thus it is safe to say that they breathe in some measure by their lungs as well as by their gills; that they must have well-aerated water; that the adults are put about by illumination, for a time at least; that they thrive best when the temperature of the water is low and uniform; that in captivity they feed on water-fleas (small crustaceans) like Daphnia and Cyclops, and on little river-worms like Tubifex. It may be mentioned that, in spite of their blindness, they can find threads of raw flesh held out towards them in the water. An examination of the stomach-contents of specimens of Proteus from the caves shows that in natural conditions they feed in part on small crustaceans (such as a cave-amphipod called *Niphargus stygius*) and on small water-worms. Of course there are no green plants in the subterranean waters, unless they are being carried past by the stream.

It is possible to get olms to breed in captivity, and thereby hangs a rather interesting tale. In the early spring the male sometimes shows a heightening of the caudal fringe, and the female, plumper than usual, shows eggs shining through the translucent skin. The eggs are fastened singly to the underside of projecting stones in the water, and a female may produce twelve to fifty-six altogether. There seems to be no certainty about the mode of fertilisation, but it must be internal, not as in the frog where the eggs are fertilised as they are laid. Each egg is about a sixth of an inch in diameter, but it is surrounded by an envelope and then by a zone of transparent jelly, as in frog's spawn, so that the diameter rises to nearly half an inch. In about ninety days the larvæ emerge, nearly an inch long, miniatures of their parents except in a few particulars. Thus there is a delicate unpaired fin that begins on the posterior part of the trunk, and is continued round the tail; the diminutive hind-legs have not yet attained to having even two toes; the eyes are distinctly visible as dark spots shining through the skin. During the development, which goes on in darkness, the embryo is quite without pigment, but when the newly hatched larvæ are brought into the light to be studied they quickly put on numerous minute spots of a brownish colour. So much then for Proteus as an egg-laying animal, but this is not the whole story.

In the Experimental Station at Vienna, Dr. Paul Kammerer kept olms in a very suitable place, a deep hole sixteen feet below the surface of the ground, constantly supplied with uniformly cold and fresh water. In these conditions the olms brought forth living larvæ instead of laying eggs! In our clumsy words they were viviparous, not oviparous. The strong probability is that the laying of eggs is an unusual method of multiplication for the olms, and brought about by lack of uniform coolness in the water. One cannot at present be quite sure, but it is likely that viviparous birth is the rule in the caves. In giving birth to the living larvæ the female is suspended at the surface of the water with the anterior and posterior parts of the body curved downwards. The birth is usually in October. If the few

observations that have been made form a broad enough basis, we may say that the viviparous method of giving birth shows an interesting economising of reproduction, for there are usually only two larvæ born at one time. It is plain that the more telescoping there is of the early stages in an animal's life-history, the more are the chances of death reduced, and the smaller the family may become without passing the limit of safety.

Proteus is in many ways of great biological interest, especially perhaps in showing the interaction of "Nature and Nurture." By "nature" is meant what is inborn—the inheritance; "nurture" includes all the influences of surroundings, food, and habits. Normally, in its dark haunts, it is almost pigmentless; but it has not lost the hereditary factor for pigmentation. For when it is brought into a lighted laboratory it soon becomes spotty—its skin is sensitive like a photographic plate—and in several months it may be quite black. If it be returned to the darkness, it slowly loses its pigmentation; and if the blanched specimen be brought back to the light it becomes dark again. Light is an external "nurture" factor necessary for the expression of the internal factor for pigmentation which still remains part of the hereditary "nature."

In the caves the eye is arrested in its development; it begins well, but retrogresses; it lies about a hundredth of an inch below the thickened skin. The creature is blind. But Kammerer has shown that if the newly hatched larvæ are reared in red light, the eye develops into a seeing eye. After five years of red light, or white light periodically interrupted by red illumination, the olms showed eyes with a transparent cornea, an iris, a large lens, a retina with rods and cones, and so on—in short, almost normal eyes. The reason why white light alone will not serve is that, unlike red light, it brings about the development of dark pigment in the skin over the eye, and this stops further progress. We could not have a better instance of the way in which "nurture" helps or hinders "nature"; in the caves the olms are pale and blind, in the sunlit laboratory they become black, under a red lamp they develop eyes that can see.

Another blind newt called Typhlomolge, a near relative of Proteus, occurs in subterranean caves in Texas. This is very interesting, for the two, though very far apart geographically, are so near one another in structure that we must think of them as having a common ancestor, probably like the Mud-puppy (Necturus) of North America. It is striking that these second cousins should have independently become cave-animals in homes so far apart as Dalmatia and Texas. The Texas cave-newt is white and blind like Proteus, and it is only known from specimens that came up with the water from an Artesian well 188 feet deep. They refused to feed in captivity and soon died.

Thinking of caves and other dark places leads us naturally to consider blind animals in general. Are there many of them? Where do they live? How do they hold their own? In the late Mr. E. H. Aitken's delightful book, called *The Five Windows of the Soul*, there is a wise sentence at the beginning of the chapter on Sight: "Before Life had a window to open to Light, Light was long knocking for entrance into Life." Thus plants have no eyes in the true meaning of the word, yet Sir Jagadis Chunder Bose has shown that a tree is sensitive to a passing cloud; and the most important process in the world (photo-synthesis) depends on the utilisation of the light by the green leaf. Many a simple animal without any trace of eyes draws towards the light, and the plants on the table near the window have to be turned round at frequent intervals towards the light to keep them from growing all askew. The earthworm has no trace of eyes, but it is very sensitive to light and shade; and there are various eyeless marine animals that react when we put our hand gently between them and the sun. There is a long inclined plane between the simple eye of a jellyfish and the wonderfully perfect eye of a gull; and it seems that the function of the eye was primarily to discriminate between light and shade, secondly to detect movements of adjacent objects, and only thirdly to form images and distinguish colours.

There are many facts that give us food for reflection. Thus there are cases, *e.g.*, among cave-fishes and cave-sala-

manders, where forms with normal eyes and forms with very degenerate eyes occur in similar conditions, which raises the old question whether cave-dwellers took to the caves because of their weak eyes, or whether the poorly developed eyes are due to disuse in darkness, or whether seeing forms got washed in by accident and those more sensitive to faint gleams found their way out, generation after generation, while those that were inclined to vary in the direction of dull vision or blindness remained.

Then there is the fact that the young stages of the cave-animals sometimes have eyes showing much less degeneration than in the adults. This raises the question whether the final going-back of the eye is not in part impressed upon the individual as the result of a lifetime of disuse and lack of stimulus. It may be that blindness is sometimes a change impressed on the individual dweller in darkness, and we know that a goldfish kept in the dark for three years became quite blind, losing the rods and cones of its retina.

NEWTS AND SALAMANDERS

Benvenuto Cellini tells us in his autobiography that one day, when he was sitting with his father before the fire, they suddenly saw a salamander basking in the midst of the flames. They both saw it plainly, but the father, being an educationist of the old school, gave the boy a sound box on the ear, so that he might remember the salamander for ever. The fire was a strange place for a salamander, which likes moisture and shade ; but the superstition lingered long that the clamminess of the creature enabled it to endure great heat and even to extinguish the flames.

So recently as 1716 the *Philosophical Transactions of the Royal Society* recorded that a salamander cast into the fire "swelled presently, and then vomited a store of slimy matter, which did put out the neighbouring coals." The only grain of truth is in the fact that a salamander in despair exudes a considerable quantity of the poisonous secretion, which it shares with the toad and many other amphibians, and that the muscular pressure may be so great that tiny

jets are squirted from the skin-glands to a distance of nearly a foot.

The fire or spotted salamander is of wide occurrence in Europe, but it is not familiar to many. It is nocturnal in its habits and hides during the day in moist and shady places. After heavy rain large numbers often appear, for they cannot resist the earthworms that come up from the flooded burrows. As the skin is rich in poison-glands the salamander has few enemies, and many naturalists believe that the conspicuous livery—large yellow spots on a black background—serves to impress on daring experimenters among animals the fact of unpalatability or worse. In short, the yellow and black are "warning colours."

Many ponds and marshland pools are frequented by newts —slow-going, tailed Amphibians, distantly related to frogs and toads, more nearly related to salamanders. There are three different kinds in Britain—the Crested Newt, the Smooth Newt, and the Palmated Newt—and they are first cousins, belonging to the genus Molge or Triton. Their shape suggests lizards, which are reptiles, while newts are true amphibians, with a naked moist skin and without claws or ear-openings. When they are young they breathe by gills, which are never seen in reptiles. Popularly the word "eft" is applied to newt and lizard alike, and the two very different creatures seem to be mixed up a good deal in ancient lore and superstitious prescriptions. Another name occurs in one of Masefield's poems, where he speaks of

> "The water-rat that gnaws the yellow flag,
> Toads from the stone and merrows from the quag."

There is something slightly repellent in the cold clamminess of the newt's skin, but no unprejudiced person can deny the animal's beauty. It has pleasing lines and its swimming movements are graceful. There is a high crest along the back of the breeding male of the Crested Newt and the Smooth Newt, and both show a pleasant yellow or orange colour on the under surface of the body. The courting dress of the male Smooth Newt includes a glittering blue stripe on each side of the tail, interrupted by vertical dark spots. Artistically regarded, newts require no apology.

For most of the year newts are terrestrial, creeping slowly about in moist places in search of small insects, slugs, and worms, or, in the wintry months, lying motionless in a hole, sometimes in little companies. When spring comes they seek out the water, and they may have a long way to go. Like many other animals, they return for breeding purposes to the racial headquarters, for newts belong to an aquatic stock, and the early gill-bearing life must be spent in the water. The only exception is when some very unusual arrangement has been arrived at, as in the Black Salamander of the Alps, where the whole metamorphosis, including the gill-bearing period, is telescoped back into the time before birth.

The newt is of course a cold-blooded animal, with a body temperature approximating to that of its surroundings; and it is temperamentally cold-blooded as well. Only at the breeding season is there any trace of excitement. The male displays himself before his unemotional mate, he shows off his flushed colours and waving crest, he kisses or butts her head, and fondles her with his very sensitive tail. But, from first to last, it is a cold-blooded business, though a necessary preliminary to the fertilisation of the eggs, which is accomplished in an unusual way. But there is not even croaking.

The eggs are usually laid singly and attached to water plants, such as the pond-weed Polygonum. Each egg is surrounded by a gelatinous envelope, and the mother newt often bends a leaf round so that the egg is not only glued on but well concealed. This is a distinct advantage, for when the eggs are left exposed on stones or the like, as occasionally happens, they are apt to be devoured by sticklebacks and carnivorous water insects. In about a fortnight the yellowish larvæ are hatched, more fish-like and more delicately built than the tadpoles of frogs and toads. They have three pairs of external gills, which become branched as they grow, and they may retain these for a long time if it is difficult for them to clamber out of the pool. If they have not completed their metamorphosis by autumn they will remain in the water all the winter, and they have been seen moving

near the bottom of the pool under a blanket of ice! But if the development goes on apace the young are ready to leave the water in autumn. They are sometimes found hidden in clumps of water-weed on the bank, but they afterwards seek out drier spots. The adults usually leave the water much earlier, returning to dry land soon after the end of the breeding season.

There must be a much lower juvenile mortality among newts than among frogs, for the eggs are not nearly so numerous, while the risks are in a general way much the same. How is it that newts have been able to survive with a much smaller family? Part of the answer must be found in the fixing and frequent concealment of the eggs. There seems to be some variability of behaviour in this respect, but the mother Crested Newt shows a glimpse of care in selecting appropriate water-plants, like the Canadian Pond-weed, Anacharis, on which the eggs are very safe. It should be noted that the newly hatched larvæ have two pairs of thread-like outgrowths on each side of the upper jaw, by which they are able to anchor themselves to water-plants. As an extreme case of the successful reduction of the size of the family we may refer again to the Black Salamander, which lives terrestrially high up the Alps, preferably near the spray of waterfalls. As we have mentioned, the young of this species develop inside the mother, and there are only two of them! Parental care makes a small family consistent with survival, and the reduction of the family makes parental care easier. This is one of Nature's virtuous circles.

Newts swim after the manner of fishes; that is to say, the muscular undulations of the posterior body and the flattened tail displace masses of water, first to one side and then to the other. The limbs are too slender to be of much use in swimming, but those of our smallest newt, the Palmate Newt, are fully webbed. When newts are crawling about on land their limbs seem hardly strong enough for their work. The newt's skin is scaleless and glandular, producing a secretion which seems to make the animal unpalatable. Breathing may take place through the skin, which is the exclusive method in frogs all through their winter lethargy;

and here we may notice the occasional disappearance of the lungs in some relatives of the newts, such as certain salamanders. Another characteristic of the skin is the abundance of sensory cells; they tend to be especially localised in a row along each side of the body, thus recalling the sensitive lateral line of bony fishes. This is one of the straws which shows how the evolutionary wind has blown; the ancestral fish is still lingering in the amphibian. The outermost layer of the skin dies away periodically, and the newt moults. In a neat way it uses its fingers to help in the disrobing; the slough is peeled off from the head backwards. No doubt the dead husk sometimes comes off in shreds, but it may form an intact slough, which is occasionally seen, hanging like a ghost of the newt, among the water-weed in the aquarium. We say "occasionally," for when the newt has got rid of its slough, turning it inside out, it normally ends by swallowing what it used to wear. The newt has a frugal mind.

There are many other interesting facts about newts, such as their successful re-growing of limbs that have been bitten off; or the way in which they occasionally produce eggs while still gill-breathing larvæ—a peculiarity probably due to something wrong with their ductless or hormone-making "endocrine" glands. But perhaps the greatest interest of newts is that they represent the pigmy descendants of large and vigorous forms that helped in colonising the dry land in Devonian and Carboniferous Ages.

XX

THE WAYS OF FISHES

THE first backboned animals (Vertebrates) to be thoroughly successful in the struggle for existence were the Fishes ; and it must be understood that for many millions of years they were the only backboned animals, apart from a few forerunners. These are represented nowadays by the Round-Mouths or Cyclostomes (Lampreys and Hags), the Lancelets (Amphioxus), the Sea-Squirts or Tunicates, and some still more old-fashioned pioneers of the ordinary Vertebrates.

Some fishes, such as sea-horses, globe-fish, and pipe-fish, are very strange ; but in most cases they are at once recognisable as fishes. Thus their limbs are paired fins, without fingers or toes ; the skin bears scales ; the breathing organs are feathery gills ; the eyes have no lids ; the swimming organ is usually the very muscular posterior part of the body. The class includes (1) the Gristly Fishes, like skate and shark ; (2) the Bony Fishes, like salmon, cod, herring, and eel ; and (3) the Lung-fishes or Mud-fishes of three different kinds : Ceratodus in Queensland, Lepidosiren in South America, and Protopterus in Africa. These mud-fishes link ordinary fishes back to Amphibians, for they have lungs as well as gills.

SENSES AND BEHAVIOUR

Most anglers are agreed that trout become wary, and there are show-ponds where the fishes crowd to the bank when the dinner-bell is rung. That means that fishes can link together certain sights or perhaps sounds with certain impulses. But we know very little about intelligence in fishes.

A dogfish becomes aware of a piece of flesh which is hidden from sight, and there is no doubt that some other fishes have a strong sense of smell. A carp may be seen trying a morsel of food and then rejecting it with apparent disgust. There is abundant evidence of the sense of taste in fishes, and it may have its seat away from the mouth-cavity altogether, on various parts of the body such as the fins. There is an American catfish that can taste its food with its tail! In various parts of the skin there is another sense—a chemical sense—that makes the fish aware of changes in the composition of the water.

Touch is not a strong point with fishes, but it is sometimes developed about the head and lips, or on feeler-like processes, one of which is well seen on a cod's chin, called barbels. If you look at almost any bony fish, you see a "lateral line" running along each side. It consists of a row of sensitive cells embedded in slime and sunk in an open groove, or in a canal roofed in by scales and communicating with the exterior by means of small pores. Experiments show that this lateral line is the seat of a sort of mechanical sense that makes the fish aware of a pressure in the water working in a definite direction. Thus when a fish is coming near a rock the recoil of the water that is displaced by the fish's movements is felt by the lateral line and the creature turns aside. Or again, it is by the lateral line that a fish becomes aware of a tributary entering a river. This sense must be of much use at night and in muddy water. It is probably concerned in the persistence with which some fishes, like migrating salmon or young eels, go straight up-stream. For it makes the fish respond to the direction and strength of the currents in the river; and fishes have an engrained obligation (or "tropism") to adjust their body (it comes about automatically) so that the pressure is equal on the two sides. It may be noted that in Gristly Fishes like skate and dogfish the place of the lateral line is taken by numerous branching jelly-tubes which lie in the skin and open by minute pores.

Oscillations and vibrations in the water are detected by some fishes, both by the ear and by the lateral line. In

some cases the sense of hearing has been proved, but in other cases the fishes pay no heed to even loud noises. This does not necessarily mean that they are deaf; it may simply mean that they are not interested. But the fact is that we do not know very much about the sense of hearing in fishes. Perhaps it may seem strange to ask whether fishes can hear, when the fact is that they have all got well-developed ears. But the ear has another use besides hearing; it is a balancing organ, especially in that part known as the "semi-circular canals." Before the ear was a hearing ear, it was a balancing ear.

As to sight in fishes, there is sometimes, as in trout, a quick detection of differences in light and shade; and the bony flat-fishes show great sensitiveness to the colour of the background on which they rest. For in a short time they are able to adjust their own colour and pattern to suit their surroundings. The colour of an object, like bait, is not perceptible at a short distance below the surface, and yet some fishes are most attracted to artificial bait of a particular colour. But few of those who have experimented with fishes have been careful to draw the distinction between different colours and different degrees of brightness. Professor Hess, who attended to this distinction, was led to the conclusion that fishes see different colours simply as different shades of grey. In other words, they are in this respect like men who are totally colour-blind. But we must be careful not to make general statements until more cases have been studied. All that we can say is that colour-blindness occurs in some fishes.

In judging of the ways of animals we must always think over the ordinary conditions of their life and the actions that are suited to these. A reliable fisherman tells us of a pike whose eye had been accidentally wrenched out with a hook, which nevertheless a few minutes afterwards swallowed that eye! We are tempted to call this action very stupid, but that would be a wrong conclusion. For what the fish did was merely to snap *reflexly* at a glittering object. It did what was probably a profitable thing to do in ninety-nine cases out of a hundred in the ordinary con-

ditions of its life. Of course the one-eyed pike did not know that it was snapping at its own missing eye!

A zoologist called Oxner has made some interesting experiments with the sea-perch (*Serranus*). In his aquarium he placed a red vessel and a green vessel, hanging them by silk threads of the same colours. Then he put some food in the red vessel. On the third day, after nosing about for a quarter of an hour, the fish entered the red vessel and



Photo: John J. Ward, F.E.S.

THREE-SPINED STICKLEBACK (*Gastrosteus aculeatus*).

This little fish, never more than four inches long, is found in the rivers and on the coasts of the Northern Hemisphere. There are no true scales, but the sides of the compressed body are armoured with bony plates, which show considerable variability in number and size.

ate the food. Next day it did the same after five minutes; on the fifth day after half a minute. From the sixth to the tenth day it rushed in at once. So it had formed a linkage or association between the red colour and the food. It was not any odour that attracted the fish, for on the eleventh day it entered a fresh red vessel that had no food in it, and waited there for three minutes. On each of the following six days it rushed into the empty red vessel, and when Oxner dropped in some food a little was eaten. But the sea-perch was not much appetised, and on the eighteenth,

nineteenth, and twentieth days it did not eat what was offered to it in the vessel. But the interesting point was that it could not resist rushing in! The colour pulled the trigger without fail. It was not the *red* colour in particular that was attractive, for the same results were reached in another set of experiments where other colours were used. What happened was a linking together of a signal (the colour) and a pleasant experience (eating the food); and this kind of "conditioned reflex" may occur in the everyday life of fishes. A certain sight pulls the trigger of a reminiscence, or of an engrained nervous linkage, and action follows—sometimes swimming towards the object if it be food, sometimes swimming away if it be an enemy.

Very pretty experiments have been made by Miss Gertrude White on American mud-minnows and sticklebacks. Two cloth packets, one stuffed with meat, the other with cotton, were hung at opposite ends of the aquarium. The sticklebacks were immediately interested in the meat-bag, darting upon it furiously and pulling it about. From the cotton-bag they turned away at a distance of about two inches. The mud-minnows were not interested in the bags, but they watched moving objects very intently.

Fragments of liver were held to the little fishes from the end of forceps and kept from touching the water. The fishes could see the food but could not smell it. To get it they had to leap out of the water, and they learned to do this neatly. Then Miss White slipped a disc of coloured cardboard over the lower end of the forceps, so that what the fishes saw was a morsel of food in the centre of a coloured circle. The fishes soon established a mental linkage between coloured disc and food, so that they could not resist jumping up to a coloured disc even when there was no food there. Better than that, the mud-minnows learned to associate a blue disc with real bait, and a red disc with paper-bait. They learned to ignore a kind of larva that they could make nothing of, and to link together the approach of a visitor and the prospect of a meal. It has been proved up to the hilt that fishes form simple associations of this sort and hold to them firmly.

Salmon come back from the sea to spawn in the rivers of their birth; elvers show an admirable perseverance in overcoming obstacles on their up-stream journey; the male sticklebacks make nests of seaweed or parts of freshwater plants; the male sea-horse carries the young ones in his pocket; the male lump-sucker guards and aerates the eggs in the corner of a rock pool. There is no difficulty in multiplying instances of this kind of behaviour; but it all seems

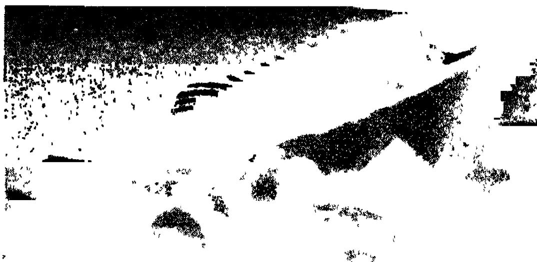


Photo: W. S. Berridge, F.Z.S.

TEN-SPINED STICKLEBACK (*Pygosteus pungitius*)

The dorsal spines vary from seven to twelve. The nest is not built on the bottom of the pool, as in the Three-spined species, but is attached to water-weeds. Except in the Far North and in the Baltic region this species is usually confined to fresh water.

to illustrate obedience to inborn promptings to go through a certain routine. It is very effective behaviour, but there is no proof of intelligent learning.

Here, however, is an instance of a kind of behaviour which shows something more. In the aquarium of the Monaco Museum, M. Oxner made some experiments with a fish technically called *Coris julis*, which seems to have no common name. He tried it with a hook well disguised, and he caught it as often as he pleased. That proved that the disguise was very perfect and that the fish was very hungry; and it suggested that the fish was of a somewhat unsuspicious

nature. Then M. Oxner placed a piece of red paper on the gut-line a couple of inches above the well-hidden hook, and offered it to an inexperienced and quite unprejudiced Coris. For the first week the fish remained indifferent ; but on the eighth, ninth, tenth, and eleventh days it took the bait. On the twelfth day, however, it refused the bait until the red paper was removed. On the thirteenth, fourteenth, and fifteenth days it refused the bait with the red paper on, though it examined it carefully. On the sixteenth day and on the following six days it began by snapping at the red paper, and then, turning to the hook, bit off the bait in small scraps, without any hurry, and with a thousand precautions. *It had learned its lesson.*

Let us think over what happened. A linkage was established in the mind of the fish between red paper and hook. The inborn or instinctive prompting was, of course, to swallow the bait, but the red paper served as a warning. It was a danger-signal which the fish obeyed. Gradually, however, the fish profited by experience, it learned a new trick, it discovered how to nibble at the bait without gulping at it and thus getting the hook into its mouth. So it disregarded the danger-signal and got its titbit. This was coming near an intelligent understanding of the situation.

We see then that fishes have many interesting habits to their credit, but they do not show more than the dawning of intelligence. By far the best brains are to be found among the gristly forms like skate and shark ; in bony fishes the fore-brain , which is the seat of intellectual processes in higher animals, is very poorly developed.

As fishes had established themselves, both in fresh waters and in the sea, during the ages called Silurian—that is to say, a great many millions of years ago—they have had time to make a great many experiments, or to test the many new promptings that arose ever and again from within.

Animals are always insurgent, always looking out for a new kingdom to conquer. If they cannot get a new kingdom, they will be content with a new corner. The great abysses of the ocean may serve to illustrate a new kingdom, which fishes have possessed. It appears as a very inhospit-

able haunt with its eternal night and eternal winter, its enormous pressure and its plantlessness. Yet many fishes are at home there, having probably followed the down-drift of food from the shore area or from the open sea. Some of them are blind and others have large goggle eyes, many have an extraordinary width of gape suited for making sure of a meal when an opportunity offers, and many are luminescent.

What a contrast between the abysmal habitat and that of some fishes which climb up mountain torrents. There are some fishes that frequent the mountain torrents of India and may be seen clambering up from stone to stone. They are almost leaf-like in shape, and this enables them the better to resist the down-rush of the current. There is a great reduction of scales on the under surface of the body, and this makes it easier for them to adhere to the smooth surface of rocks. We know how tightly two sheets of wet glass will cling to one another. The paired fins may also help as holdfasts, and some kinds of mountain-torrent fishes have special adhesive organs. The eyes are much smaller than usual and are pushed towards the upper surface. In short there are various adaptations which enable these climbing fishes to succeed in their strenuous mode of life.

In estuaries and fresh waters of India there lives the so-called Climbing Perch (*Anabas scandens*), whose native name means "the fish that climbs palmyra trees." Its climbing powers have been exaggerated, it is true, but they are remarkable. Mr. Wilson, of the Madras Fisheries, once trained a few of them to ascend a nearly vertical sheet of cloth dipped into the water of the aquarium in which they lived. They learned to swarm up, using their movable gill-covers and spines. It is well-known that these Climbing Perches sometimes make considerable excursions on land.

There is a curious complication of the breathing arrangements in the Climbing Perch. It has the usual fish-gills, on which the blood is spread out, but one of the gill-arches has a complicated bony labyrinth with many blood-vessels on its wall. Air is gulped in at the mouth; it passes into the labyrinth; it loses part of its oxygen to the blood-vessels

and absorbs carbon-dioxide; and then passes out by the gill-chamber.

The late Dr. Nelson Annandale, of the Indian Museum in Calcutta, described another climbing fish, which ascends the posts supporting wooden houses built over the water by the shores of lakes. This little fish moves slowly up the post, browsing on encrusting plants and animals. It seems to use its tail in climbing, after a fashion which recalls the woodpecker's way of pressing its stiff tail-feathers against the roughnesses of the tree-stem. When the little fish wishes to rest on its ascent, it takes firm hold with its lips.

Widely distributed on tropical shores is the mud-skipper (Periophthalmus) which jumps about when the tide is out and hunts small animals. It is famous for its protruding eyes which stand out on the top of its head and look all round. In its life out of water it seems to breathe in part through the blood-vessels richly spread out on its tail. This mud-skipper is sometimes to be seen fairly high up on the above-ground roots of the mangrove trees, and one might speak of it as a fish that climbs trees! The fore-limbs or pectoral fins are muscular enough to be used as little legs. A fish out of water indeed, but a conqueror of the shore!

These are strange haunts and strange ways for fishes, and many more might be noticed. But the point is simply to illustrate the pioneering of some fishes. We have not to do with curiosities, but with the tendency of animals to seek out *vacant niches of opportunity*, new corners in which they can escape for a time from the keen severity of the struggle for existence.

THE QUEST FOR FOOD

Along many different lines fishes have tried to solve the "bread-and-butter" problem. There are a few that have vegetarian diet. Thus the long food-canal of the Mediterranean Bogue or Box seems never to contain anything but fragments of seaweed and sea-grass. The Rudd of British streams might also be called a vegetarian, though not absolutely consistent. The fact is that most fishes that eat

water-plants and seaweeds like a good deal of fleshy relish in addition. And there is an inclined plane leading to fishes like carp, which will eat anything and everything. At the lowest level are those offshore fishes that depend mainly on what may be called sea-dust — the organic crumbs that are washed out from the seaweed zone.

The carnivorous fishes are legion—the shark devouring other fishes, the dogfishes fond of octopus, the skate preying on crabs and oysters, the pike thinning the trout, and so on through a long list. But rather different from these predatory forms which feed at a high level, are those that depend on relatively minute creatures which are sifted out of the mud or caught among water-weed. Thus many fresh-water fishes depend to a large extent on the aquatic larvæ of insects like Mayflies, and the stomach of a trout is often found stuffed with scores of small fresh-water snails and nothing else. Highest of all, in a way, are those dainty feeders, like herring and mackerel, sardine and sprat, which depend on the minute and sometimes microscopic plants and animals (the plankton) of the Open Sea. These plankton-eaters are usually very palatable, as one would expect from the delicacy of their diet.

So far the common solutions of the problem of food-getting among fishes, but against this background, to illustrate plastic " ways," let us notice a few strange methods. Thus it is recorded of more than one kind of " Javelin Fish " (Toxotes) in Indian streams, that they get part of their sustenance by squirting jets of water from their mouth on passing insects. What a contrast to the behaviour of the Sword-fish (*Xiphias gladius*), which has a long, pointed, sword-like prolongation of the upper jaw with which it sometimes transfixes a Tunny or even a porpoise. It has been known to send its sword accidentally through the two-inch plank of a vessel. There is less certainty as to the Sawfish (*Pristis antiquorum*), which has its snout prolonged into a broad saw, often over a yard in length, with a row of strong, sharp, socketed teeth, projecting at right angles on each side. It is believed by some naturalists that the Sawfish cuts off great pieces of flesh from its booty ; but others maintain that

the chief use of the saw is to rout up the mud at the bottom of the sea, so as to expose the molluscs and crustaceans on which the fish feeds. This requires further investigation.

How different again is the habit of some of the electric fishes, such as the Torpedo and the Electric Eel, which use their powerful battery, not merely in offence and defence, but in paralysing or killing their prey, which often consists of other fishes. As a last example of plasticity take the Sucker-fish or Remora (Echineis), which has an elaborate sucker on the head and anterior dorsal region, by which it fastens itself to sharks, other large fishes, turtles, cetaceans, and even ships. The little Remora does its living bearer no harm, for it is no parasite ; it hangs on for the sake of transport and because it may share in what its bearer secures. Semon observed in the Torres Straits that when edible material was thrown out of his boat, a number of Remoras darted out from beneath, seized some of the food, and then fixed themselves again. It is difficult to think of the origin and evolution of this extraordinary habit and others like it without allowing fishes at least a trace of the experimental mood. The association between the Remora and its bearer must have been sustained for a long time, for the attaching sucker is an elaborate contrivance. The association must also be very constant in the individual, for the lower surface of the Remora is darker than the upper one, which is next the bearer. This is, of course, quite contrary to rule. One must not forget the human touch, that on the East African coast and elsewhere the native fishermen tie a line to the Remora's tail and let it loose in the sea to find a turtle. When the Remora has fastened itself to the reptile, true to its inborn aptitude (or " reaction-tendency "), then the fishermen pull in the line very carefully and secure the booty. Then the Remora is sent a-fishing again.

PARENTAL CARE JUST BEGINNING

Few fishes have any use for parental care. They have such large families that there is a big margin for casualties. It is often said that a cod may have two million eggs, and a

conger-eel ten million ; and though these numbers are perhaps too large, there is no doubt that fishes spawn profusely. Parental care in most fishes is neither necessary nor possible. There are exceptions, however, where the number of eggs is small, and where parental care occurs. The two factors work together. If a reduction in the number of eggs has come about, then the race will be continued only by those individuals who change in the direction of taking good care of them. On the other hand, if there is successful parental care, then changes in the direction of reducing the size of the family will be practicable. This is not a vicious circle, it is a " virtuous circle," and the story of evolution has many another example.

In skates and rays, in many dogfishes and sharks, there are comparatively few eggs, and these are large in size. Each is enclosed in a shell of horn—the " mermaid's purse " of skate and dogfish—which often becomes attached to seaweed or rock, so that the young embryo is not smothered in the mud. Still more certain of securing safety is the method seen in the Torpedo and in many dogfishes—the young ones are kept within the mother until they are able to fend for themselves. In a few cases there is a further improvement, for a close connection is established before birth between the offspring and the mother—a far-off anticipation of what occurs in ordinary mammals. This is seen, for instance, in most species of the dogfish called Mustelus, and it is very interesting to note that the state of affairs was quite clearly understood and described by Aristotle more than two thousand years ago.

As the seashore is a changeful and strenuous place to live in, we are not surprised to find parental care illustrated by some of the fishes that have their home there. The butterfish, or gunnel (*Centronotus gunnellus*), which is very common in shore-pools and very well adapted for slipping through narrow chinks, is in the habit of rolling its eggs into a little ball, and then twisting its body round them. It often secures additional safety by getting into a hole which a piddock or a sea-urchin has bored in the rock, or even between the valves of an empty oyster-shell. It seems to

be still uncertain whether this beginning of brooding is on the part of the male only or of both parents. In any case we have to do here with parental care without complications.

Another step has been taken by the Lumpsucker or Cock-Paidle (*Cyclopterus lumpus*), a quaint, stocky fish with its hind limbs (pelvic fins) transformed into an adhesive sucker, situated far forward. The brightly coloured pinkish or yellowish eggs are laid in a large mass in a niche among the low-tide rocks. The male pushes the mass of spawn firmly into the crevice, and makes deep conical depressions on the surface, which allow the water to get well in towards the centre of the clump. He then mounts guard, driving away hostile intruders, removing crawling creatures like starfishes, crabs, and whelks, and aerating the eggs by driving in currents of water by energetic contractions of his gill-cover. During this strenuous exercise, the male holds on to the rock by his sucker. He sometimes vibrates his body so excitedly that a sound is produced! He has been known to draw blood by biting at the hand of a too inquisitive observer. His devotion, if one may use the word without implying too much, lasts till the young ones hatch out.

The Toadfish (*Batrachus tau*) of North American coasts leads us a step further. Several females fix their eggs in a hole in the rock, or within an empty shell, or even inside a tin, and the male mounts guard. He expels intruders and he remains at his post even at very low tide. When the young ones are hatched he is careful to keep them within bounds until they are ready, and he seems to be happy in sheltering them beneath his pectoral fins. It is plain that we do not get an adequate impression of fish nature unless we consider cases like this.

The Bow-fin (*Amia calva*) of the Great Lakes of North America makes a nest among the reeds and rushes by biting off the stems over a circular area. The eggs are laid on the floor of this clearing, and the male mounts guard. He is sometimes quiet for hours; but, at intervals, he effects artificial aeration of the eggs by making very energetic

respiratory movements with his gill-cover. After the young are hatched, they are led about and defended by the male fish. Dr. Bashford Dean writes: "He appears to be constantly watchful, and when alarmed exhibits the greatest solicitude for his charges. Sometimes he backs quietly into some reed-screened pool, hiding below in the shadow of floating weeds, his presence only betrayed by the black



Photo: W. S. Berridge, F.Z.S.

EGG PURSES OF DOGFISH.

The eggs, enclosed in pale yellow horny shells, or "purses," are laid late in the year, and the long thread-like tendrils, one from each corner, serve to moor them to zoophytes or seaweed, so that they are less likely to be smothered or injured. The young dogfish escapes at one end.

mass of larvæ about him; at other times he will slip cautiously away, drawing the swarm after him as rapidly as possible." When discretion is impossible he has recourse to valour, and will face a formidable enemy. The youngsters usually remain under the paternal care for several weeks, but in some cases the period of tutelage lasts much longer.

The Gourami is a large freshwater fish of the Malay Archipelago, which has been introduced into many parts of the world, such as Madras. It grows nearly two feet long, and its flesh is very palatable. At the breeding season

it makes a nearly spherical nest of water-grass and the like, and usually fastens it to plants growing at the margin of the pond. At this time the fish assumes a jet-black colour and flashing red eyes, and becomes very pugnacious in defence of the nest. The Gourami is one of those fishes that can use dry air gulped in at the surface, and a very interesting fact is that every now and then the mother



Photo : W. S. Berridge, F.S.Z.

HEAD OF DOGFISH.

As in other gristly or cartilaginous fishes (Selachians), the mouth is ventral, not terminal. The jaws bear small but strong teeth, suited for eating crabs and lobsters. In front of the mouth are seen the two nostrils; the eyes are deeply insunk; on each side of the neck there are five gill-slits for the passing out of the water that enters by a spiracle—a dorsal gill-cleft behind the eye.

brings down a mouthful of air and discharges it upon the eggs, thus securing their thorough aeration. Here we have a fish puffing air on its eggs! Surely that is *experimental.*

Let us take another instance from India. It concerns a fish called Etroplus, common in weedy ponds, ditches, and rivers near Madras. About two hundred eggs are laid in a shallow cup-like nest scooped out in the bottom débris and lined with green silky fibres. The two parents mount guard at the nest; and every now and then they carefully

scrutinise the eggs. But Mr. Sundara Raj tells us of a sight he saw which looks like something unique. After the eggs were hatched, he saw the mother-fish dig at the root of a water-plant, get a mouthful of dark sediment, and discharge this into the nest. Unless there is some misunderstanding, this looks like the mother feeding the young fry! However this may be, when the young fishes leave the nest they move about for a while in company with their parents, by whom they are courageously protected until able to look after themselves.

There are strange elongated fishes called Pipe-fishes or Needle-fishes, which show interesting gradations in their parental care. Thus, in one of the North Sea Needle-fishes, the eggs are attached externally to the male, while in others (Syngnathus) there is a special cavity formed by two longitudinal folds on the male's ventral surface. When the males and females come together, the female puts some eggs into the front of this space, where they are fertilised. The male afterwards packs them in and asks for more. In some cases there is an exudation from the blood-vessels in the two folds, and this serves as nourishment for the young ones. In an Indian Ocean Pipe-fish (a kind of Solenostoma) it is the female that takes charge, and the pocket is formed by the hind limbs or pelvic fins.

But the climax is reached by the whimsical sea-horse (Hippocampus), common in the Mediterranean, a little fish with a head like a horse's, a prehensile tail like a monkey's, and a beautiful fan-like dorsal fin that vibrates with great rapidity. The male gets the eggs just as they are liberated by the female and stows them away in a capacious brood-pouch on the ventral surface. This pouch is formed by the closing up of two folds just as in the Pipe-fishes, and its opening is at the front end. The male receives only a few eggs from the female, but he soon gets more from other females. When his pocket is full it is closed. In the interior there is a spongy tissue rich in blood-vessels and in this the eggs are separately embedded. There is an exudation from the blood which affords food to the young fry. When they are ready the pocket opens up along the line where the

two folds joined, and thus the family is liberated. According to Professor Doflein, who is generally punctiliously accurate, the young Sea-Horses may return to the paternal fold if danger threatens, but this is vigorously denied by others.

In this remarkable case and in some others approaching it, the number of eggs is small, and, as we noted to start with, this throws light on the need for parental care.

In the case of the New Guinea freshwater Kurtus, the male fish carries the eggs on the top of his head, but there are even stranger devices. In some kinds of fish belonging to the genus Arius the male carries the eggs in his mouth, which seems to imply that he fasts until they hatch and the young ones escape. In some cases it is the female that surrenders her mouth to maternal care. In the South American Aspredo the fertilised eggs become attached in little stalked cups to the under surface of the mother, reminding one quaintly of the Surinam Toad, which bears her progeny on her back.

Professor Doflein cites the peculiar case of Brazilian fishes belonging to the genus Geophagus, where both parents seem *at times* to carry their young ones in their mouth. This is partly to save them from danger and partly to transport them to suitable places. Even when the young fishes have grown to be of considerable size they may seek safety within the parental mouth!

The question rises why parental care in fishes, which is exhibited only by a very small minority, should be usually paternal and only rarely maternal. It is difficult to answer this question, but in some cases the female is much exhausted after spawning and may even die. The male is the more vigorous of the two.

But if parental care is exhibited only by a very small minority of fishes, why should we give it so much prominence in this book? Our answer is that it gives us a glimpse of possibilities in the nature of fishes that we should hardly have expected from a study of their everyday life.

THE SALMON'S YEAR

The anatomist becomes so familiar with the body that he can see right through it with his eyes shut, and picture every organ in its proper place. So the naturalist gets to know some animals so well that the story of their year unrolls itself before him, as in a film. No doubt there are in many cases gaps and jerks which represent the imperfections in the naturalist's knowledge, but for a good many animals, like the frog and the eel, the gnat and the bee, the film is almost continuous. The salmon is one of these well-known animals, and the task nowadays is to pass from the well-worked-out consecutive description to a study of the physiological and historical impulses behind the events. Just as palæontography—a description of the succession of animals in the rock-record—passes slowly into a true palæontology, an account of the factors in the racial history or evolution, so in the study of life-histories must we try to pass from the 'graphy to the 'logy, if one may so say. But the sequence of events in the salmon's year is what concerns us here.

During the coldest part of the year, about mid-winter, the female salmon ploughs her furrow in the gravelly bed of the stream, often seeming to choose a stretch where the stones are not too unstable. With strokes of her tail she makes the "redd," and the eggs pass from her like amber-coloured beads. With flicks of her tail she half covers them with small stones, and the male liberates upon them the fertilising milt, which is very largely washed down-stream and wasted. This spawning may be observed by day, but in most cases, we believe, it takes place in the darkness. Mr. W. L. Calderwood, Inspector of Salmon Fisheries for Scotland, has called attention in a recent paper to the interesting combination of adhesiveness and resilience in the newly extruded salmon's egg. For a short time after fertilisation the egg is slightly adhesive, and is not very easily detached from stones by the current. At the same time the egg readily rebounds from stones which it strikes. "The egg may be likened to a gummed ball which will still

bounce off objects, but when once at rest will slightly adhere to any of them until, as it were, the gum is washed off." In spite of this, there must be a considerable wastage, not by crushing, but by washing away; and among the eggs that are safely caught among the stones there is about 15 per cent. of failure because of non-fertilisation. Nature works with a big margin, however, and a salmon weighing twenty pounds may liberate 17,000 eggs. Not that this is a large number compared with that produced by marine fishes like the cod and the conger-eel.

In the course of the spawning the female and male salmon move slowly upstream and repeat the same process till all the eggs are laid. The spawning bed of a single pair may cover five or six feet of ground. The male takes no part in making or covering the bed, but he fiercely drives off rivals and intruders. When the work is over the female retires, utterly exhausted, to a deep pool to rest, and the male follows a little later. But the mortality among the males is great, and many of them do not survive to return to the sea.

Vital processes involve chemical reactions, and these are quickened or slowed by higher or lower temperature. Thus it is readily intelligible that the salmon's egg should develop very slowly in the cold water in the winter months. With great deliberation—so unlike the hurry of the blow-fly's egg developing in the exposed flesh on a summer day—the salmon's egg realises its inheritance. Out of the apparently simple there is built up the obviously complex; brain and eyes, heart and gills, "in continuance they are fashioned while as yet there is none of them." When about three months have passed, the eggs hatch.

Out of the eggs come alevins, encumbered by their legacy of yolk, which protrudes in a ventral sac and hinders rapid movement. The alevins move in a helpless sort of way in the chinks among the stones, and they are anything but obtrusive. The yolk-sac becomes smaller and smaller, however, and in a month, or it may be in two months, the alevins have changed into inch-long, freely moving fry, able to fend for themselves.



Photo: G. H. and W. S. Pitt.

THE VEIL-FISH OR RYAKIN, A JAPANESE FANCY GOLDFISH.

In the fancy breed called the Veil-fish, derived from the wild Carassius, the body is short and stout, and the tail-fin is greatly elongated and so flexible that it has been compared to a lady's veil. The Chinese breed their goldfishes in very insanitary conditions, and freaks are of common occurrence.

It is now April, about five months after the liberation of the eggs, and the waters show the usual spring renascence of small animals, such as insect larvæ. These furnish food for the salmon fry, which may be seen darting about in pursuit, often coming near the surface. They may grow from an inch and a third in May to three inches in October, when the food supply gives out. The fry have to live a very quiet life throughout the winter.

In the second year the fry grow into parr, which often

reach a length of five or six inches. They are like small trout, but much more graceful, and they show eight or nine more regularly arranged " finger-marks " on each side of the body. These marks are due to patches of cells containing dark pigment; they belong to the under-skin or dermis, and they are seen through the transparent scales and through the transparent epidermis which lies outside everything.

In the following spring, when the young fishes are beginning their third year—of course there is considerable variability in the punctuation—the parr changes into a smolt. The scales have become more substantial and more silvery, and this masks the parr's " finger-prints." The smolt puts on its silvery sea-jacket, and there is a subtle change in the constitution. In some way that we do not yet understand the smolt hears the call of the sea. There is probably some internal chemical messenger or hormone at work; at any rate the fish becomes restless. Imprisoned smolts have been known to throw themselves out of the tank when the call came.

In the salt water, with its abundant nutrition and stimulus, the smolts change into grilse, but the intermediate phases are little known. The scales of a grilse show, for its sea-life, a summer zone, a winter-band, and the beginning of a second-summer zone; and at that age, say three and a half years old, the grilse may enter the river in the summer months, to spawn in the fall of the year. But there are some fish that pass through their grilse stage without ascending the rivers, so that what spawns is a salmon. Moreover, some salmon remain in the sea till they are five or six years old. The fact is that salmon show notable individuality, so that the precise shape of the life-curve differs in different parts of the country, and even in the same river for different types of fish.

There is some work to be done in discriminating the structural and constitutional peculiarities of different stages in the salmon's life-history. Thus, although a grilse is well known to differ from a perfect salmon in shape and scales and teeth, the definition requires to be made more precise.

The same may be said in regard to the differences between a "maiden fish" and a "kelt," spent after spawning.

The life-history of animals has often been likened to a Mirza bridge, which only a few individuals succeed in crossing. How true this is of the salmon! How many eggs are swept downstream, how many are left unfertilised. Eels seek out the alevins, trout gulp down the fry, pike devour the parr, coalfish wait for the smolts at the mouth of the river, seals harry the grilse in the sea, the kelt devours its own kind, and the otter finds the spent kelt an easy prey.

The word salmon means "leaper," and the ascent of the rapids is the climax of its life—and an emblem of the insurgence of living creatures in general. We have spoken of the salmon's individuality, and that is to be kept in mind when we discuss whether the conquest of the river is or is not achieved on an empty stomach. Some salmon coming up from the sea may have an occasional meal or be tempted by the reminiscent or merely intriguing bait; but the big fact is that the adult salmon urged against the stream, is *in the main* living on the store of energy it accumulated in the sea. We wish we could make up our mind whether the salmon is an aboriginal fresh-water fish that has taken to colonising and exploiting the sea, or whether it is an aboriginal marine fish that has learned to seek spawning-safety in the rivers. But whichever answer is given, we must hold to the illuminating idea that the salmon is "a historic being"—a personality at a fish-level—whose present behaviour is ruled by a past that never dies.

How do we know the various chapters of the salmon's life-history, since it is not possible to follow the fish on their migration from fresh water to salt, and from salt waters back to fresh waters?

There are three chief ways in which this knowledge has been gained: (1) Much light was thrown on the salt-water phase by observing the smolts continually on their way to the sea, and then fishing for them throughout the whole year, so as to note what food-fishes they followed, and what size they were at different seasons.

(2) Some fish were marked by fastening a piece of silver

wire with a numbered plate attached to the base of one of the fins. It was found that the fish thus marked nearly always came back to the same river, thus the length of their stay in the sea could be reckoned.

(3) Most interesting and fruitful of all is the third method, that of reading the history of the fish as it is written on its scales. For the scales go on growing throughout the lifetime of the salmon, not evenly and regularly, but at a rate corresponding to the conditions of food supply and temperature. Thus in winter the glowing scale forms circular ridges that are very close together, while in summer, when food is abundant, the rings are further apart. When the salmon go up the river to spawn, growth ceases for the time, and the edges of the scale become worn and ragged. When growth begins again and the next ring is formed, this " spawning-mark " remains visible. Thus a trained observer is able to read from a scale under the microscope how many winters the salmon has lived and how many summers, and also how many times, and at what intervals, it has spawned.

THE STORY OF THE EEL

Of all life-histories the strangest is perhaps that of the Common Eel, and it is only within recent years that it has come to be known with some approach to completeness. We shall begin with the eel nearest home, namely, in the ponds and quiet reaches of the rivers.

The cylindrical shape of the body is well suited for wallowing in the mud and creeping in and out among stones, and the eel likes to have things touching the surface of its body. A common length for a full-grown female is a yard ; twenty inches is about the limit for a male. The males take four and a half to six and a half years to grow up ; but the females take two years longer. It seems to be during these last two years that the female shoots ahead in size. During the growing time there is a good deal of yellow about the eel, along with tints of grey, brown, and green ; but when they are becoming full-grown they put on a silvery dress. So the growing fish are called " Yellow eels " and the breed-

ing fish " Silver eels." We may say at once that eels never breed in freshwater.

There are many pecularities in the structure of eels. Thus there are no hind fins (corresponding to our legs) ; the mouth is particularly well suited for voracious eating ; the opening into the gill-chamber is very small, so that an eel can remain a long time out of water without great inconvenience, for the gills do not become quickly dry. There is no doubt that eels can move across a meadow from a pond to the river.

It is often said that an eel has no scales, but this is a mistake. There are plenty of them, but they are small and somewhat deeply embedded in the slimy skin. We can tell the eel's age by counting the more or less concentric rings of growth on the scales, but we must always add three years, for the eel does not show any scales till it is three years old.

The eel might almost be called a beast of prey. It is against all other fishes, and much more than that, for it devours worms, freshwater crayfishes, frogs, water-fowl, and water voles. In his very useful book, *British Freshwater Fishes* (1911), Mr. C. Tate Regan gives a curious example of the eel's range of appetite. " Not many years ago a large eel was captured in a pond near Sherborne by a labourer, who noticed a swan in difficulties and went to see what was the matter ; the bird had put its head under water and this had been seized by the eel, who would not let go until it was in the grasp of the man, who landed it." While eels will attack anything that they have any chance of swallowing, they are seldom devoured themselves except in their youthful or elver stage.

Eels are like owls, they hunt for the most part at night. The day is spent underneath stones or in the mud and sand. They are said to become restless during a thunderstorm. While growing eels are *for the most part* freshwater fishes, it must be noticed that some find suitable feeding-places in the estuaries, or about harbours, or even in shallow shore-waters near river-mouths.

After a variable number of years, the eels begin to be full-

grown and ripe. Their appearance changes, as we have mentioned, for the colour becomes silvery below, the eyes become larger, the snout is less flattened, the fore-fins become longer and dark in colour. The eel is putting on its sea-dress. There is also a change in habits, for the eels lose their appetite and the food-canal shrinks. As the jaws are not being used much the muscles become smaller, and this changes the shape of the mouth. The composition of the blood changes also. For instance, there is more carbonic acid gas in it than there was before, and perhaps this has something to do with the restlessness that seizes the fish. It feels that it must set off on a journey, and the time for starting is usually the autumn and at nightfall. We have seen a throng of them coming down a river in the late evening.

There is sometimes a difficulty in getting out of the pond; for instance, the sluice may be shut. But the restless eel may wriggle out of the water and travel for some distance over the damp grass. But there is another difficulty, that the fishermen, who know when to expect an "eel-run," place sugar-loaf-shaped nets in suitable places in the river, and catch the fish in large numbers. The flesh of "silver eels" is preferred to that of "yellow-eels."

But many of the eels reach the sea, and that is the first stage in their journey. What has been thoroughly established, especially as the outcome of seventeen years of research by Dr. Johannes Schmidt, is that the eels have a long journey before they reach a suitable place for breeding. From the Baltic, from the North Sea, and from the Mediterranean, they come crowding into the Atlantic. They cannot become quite ripe except in the sea, and not any sea will do. Thus most of the North Sea is too shallow for them, and where it is deep enough it is too cold. They have to go far afield. What Dr. Johannes Schmidt has shown is that the European eels have their breeding-place in the western Atlantic, between about 22° and 30° North latitude and about 40° and 65° West longitude. The central part of the breeding area lies about latitude 26° N., nearly midway between the Leeward Islands in the West Indies and

Bermuda. From this area, on one occasion, the net brought up close upon 800 very young eels. This single haul was enough to show that the cradle of the eels had been discovered. After spawning the parent eels seem to die. They never return to freshwater.

This is such a remarkable discovery that we must give Dr. Schmidt's own words. He pictures "hosts of eels from the most distant corners of our continent shaping their course south-west across the ocean, as their ancestors for unnumbered generations have done before them. How long the journey lasts, we cannot say, but we know now the destination sought: a certain area situate in the western Atlantic, north-east and east of the West Indies. Here lie the breeding-grounds of the eel." Dr. Schmidt must have enjoyed a thrill of triumph when he wrote these simple sentences—condensing the patient inquiries and hard work of seventeen years.

The free eggs of the eel are not yet known, but they are probably liberated in spring and early summer. Very delicate young ones (or larvæ) about $\frac{1}{5}$–$\frac{3}{5}$ of an inch in length, are found floating in water-layers about 600–1000 feet below the surface, where there is very little light and a temperature of about 20° C. They feed on microscopic creatures and grow quickly, reaching an average length of about an inch in their first summer. They rise to near the surface (75 to 150 feet), or sometimes even to the surface itself. There they find themselves in the grip of an eastward movement of the surface-water, and they begin their journey towards the coasts of Europe. Before their first summer is over they are on their way, though they are still confined to the western Atlantic, west of 50° West longitude. We shall leave out for the moment those young eels that are going to America, and follow those that are going to Europe.

By their second summer the young eels are on an average about two inches long, and most of them are in the central Atlantic. What like are they? A young eel in its second year is like a leaf or the small blade of a pen-knife. It is quite transparent, all but its eye; it is like a living piece of

glass. It must be noted that naturalists knew them long ago, in 1856, and gave them the technical name Leptocephali, which means smooth-headed. But no one had any idea that these transparent Open-Sea fishes were the young stages of the Common Eel. There are others like them which we now know to be the young of the big six-foot-long Conger Eel which does not leave the sea. But let us return to the journey.

In their third summer the young eels are approaching the coasts of Europe, and they are about three inches long. They are still like transparent knife-blades, but they are soon going to change their shape. They swim in a leisurely way with beautiful undulations of their leaf-like body, and they are able to float at rest, almost invisible in the water. Perhaps they escape the hungry eyes of sea-birds by being so glassy.

In the course of the autumn and winter following the young eel's third summer, something very remarkable happens. The little creatures lose their appetite, and whenever animals do that, we may look out for some great change. The body changes from a knife-blade-like shape to a cylindrical shape, about the thickness of a bone knitting-needle. In the course of this change the young fish becomes lighter in weight and shorter. This is strange in a creature that is getting older, but the puzzle is solved when we remember that it is fasting. It is using the old material to build up the body on a new plan, and as it is expending energy without income, it must become lighter in weight. What is the result? The young eel has now become an elver, about two and a half inches in length, of a tougher constitution than before, ready to go up the rivers. It is about three years old, and it searches along the coasts for the river-mouths. Some have a much longer journey than others; it is easier to find the Severn than the Aberdeenshire Dee; the Mediterranean is less remote than the Baltic. Those elvers that ascend the Baltic rivers must have a journey of over 2000 miles behind them!

The elvers' ascent of the river in the Spring months is a striking sight to see. It is called by the Anglo-Saxon name

"eel-fare," which means eel journey. There are such crowds of small swimmers that a thousand may sometimes be caught in a bucket. They prefer the sides of the river to the mid-stream rush of water, and they are, so to speak, wound up to go straight on. This is a curious point—the elvers are *automatically obliged* by their constitution to adjust their body so that the water presses equally on the two sides, and this keeps them straight. If they come to a tributary they may adjust themselves to the new current flowing in, and thus they go straight up the stream. The compulsion to go up and up must be very strong, for if they come to a waterfall they swarm up the wet moss-covered rocks at the sides and thus circumvent the difficulty. Some naturalists say, however, that those young eels that are going to be males some years afterwards are not inclined to go so far up-stream as the future females do. They lag behind; the females press on.

But the up-stream journey is continued only by day. We have watched the elvers passing in hundreds, the head of one almost touching the tail of another; but suddenly, when the sun went down behind the hills, there was not one to be seen. They had all snuggled under the bank or under stones.

In Switzerland eels have been taken in waters at an altitude of 3000 feet above the level of the sea, and eels are abundant in the Lake of Constance, which is above the great Falls of the Rhine at Schaffhausen; but this is perhaps to be explained by the elvers getting round by some circuitous waterway. Sir Ray Lankester says in his delightful *Science from an Easy Chair* (1910), that he has trustworthy reports of the very rare occurrence of eels in streams connected with the Danube, yet there is no eel-fare in that river. "There can be no doubt that they have made their way individually into the Danube 'system' by migration through canals or ditches from tributaries of the Rhine or the Elbe."

The Niagara Falls are, of course, barriers to the up-stream journey of the elvers, but an American zoologist, Professor Baird, writes that "in the spring and summer the visitor

who enters under the sheet of water at the foot of the Falls will be astonished at the enormous numbers of young eels crawling over the slippery rocks and squirming in the seething whirlpools." He goes on to speak of hundreds of wagon-loads. But the Falls are impassable.

As to the occurrence of eels in shut-in ponds, it must be understood that elvers may ascend a drain-pipe or a driblet of water, and that they may press through a damp meadow. It sometimes happens, as in the North of Italy, that elvers are guided into suitable places; and they are often captured in places where eel-fares are thronged, and then introduced into ponds elsewhere. In any case many of them reach ponds and lochs after a prodigious journey; and that brings us back to where we began. Let us write the story down in summary: Full-grown "Silver-eels"—from ponds and lochs—by rivers—to the sea—the western Atlantic. Spawning and the death of the parents. The long journey of the glassy larvæ—the elvers—the eel-fare—the growing time of the "yellow eels."

STICKLEBACKS

That the interest of an animal is not in proportion to its size, is well illustrated by the sticklebacks. They are the smallest of the British freshwater fishes, but they are among the most interesting. They have a strong pugnacity linked to an equally strong paternal care; they have quaint ways and much variability. There are at least three distinct kinds on the British list: the three-spined, the ten-spined, and the fifteen-spined sticklebacks; and these are usually referred to three *genera*, which means a much bigger distinctiveness than if they were three different *species* of one genus.

The three-spined stickleback (*Gastrosteus aculeatus*) is widely distributed in the Northern Hemisphere, both in rivers and in the sea, from Kamschatka to Spain, from Alaska to California. It is a good example of a big soul in a little body, for it fears no foe although it is never over four inches long. In some localities, especially in the north,

it is chiefly marine, and may form a choky part of the palatable ichthyological collection called "whitebait"; in other places, like the Mediterranean Basin, it is practically confined to freshwater. Its external characters often differ in detail in different habitats. It is a plastic creature. A sudden transference of freshwater sticklebacks into the sea is apt to be fatal; but individuals that live in estuaries, where the water is betwixt and between, are quite comfortable whether they journey riverwards or seawards. In both habitats they sometimes occur in shoals, which feed greedily on insect-larvæ, small crustaceans, and worms. They cannot be acquitted from the charge of devouring the eggs and fry of other fishes. Their appetite is large, and they hang on like a bulldog to their victim. Their pertinacity of grip leads to ready capture at the hands of youthful anglers who need little skill to land a "tittle-bat."

When the breeding season draws near, usually about the end of spring or the beginning of summer, the sticklebacks put on their wedding robes. The dark green of the back spreads in bars down the sides; the under surface becomes brilliant red in the males. The same part is usually silver or gold in the females, who seem to be greatly in the majority. In an overflow pool of the river, or in some quiet shallow reach, or in a shore-pool near high-water mark, the male builds his nest. In this species it is constructed of pieces of plants, which are tied neatly together by means of sticky threads which exude from the kidneys. The result is like a barrel lying sideways, about an inch in diameter, with an opening at one of the ends, or like a dome with the opening at the top. It is attached to the bottom of the pool. The making of the nest occupies several days and the male is very intent on his work and very jealous of intrusion. After it is finished he goes in search of a mate, whom he courts with evident piscine enjoyment. He leads her to the nest, partly by cajolery, and partly, if need be, by coercion. She enters, lays a few yellowish eggs, and after four or five minutes breaks her way out at the end opposite that by which she entered. She is off without a good-bye, and the subsequent proceedings interest her no more. The male

then enters the nest and fertilises the eggs. Next day the little polygamist is off after another mate, and the process is repeated, until there are a good many eggs in the nest. The number must be such as to counterbalance the chances of death—for this is the law of life. The male stickleback is no stickler as to the number of his wives.

Not only does the male guard the nest from the intrusion or indifferent approach of another animal, he fights with his next-door neighbours furiously. These combats afford opportunity for a brilliant display of the masculine wedding robes, for under the excitement the red pigment-cells seem to become larger, so that the total colour is more intense. The fighting is often far from playful, for one "Jack Sharp," to use another of the many names, may rip up his rival, using the hinged dorsal spines as weapons. The male, victorious in love and on the field, then becomes more domesticated. He takes up a maternal rôle, mounting guard over the nest. With his mouth he mends breakages and with his fins he fans so that the contents of the nest are well aerated. With his mouth, by and by, he catches hold of the youngsters if they try to hurry away too soon from the guarded safety of the nest, or, more strictly, of its foundations, for it is in great part dismantled after the larvæ are hatched. In any case, if one may use the expression of a fish, the male stickleback's hands are kept very full until the family starts on the adventurous voyage of life. There are perils enough ahead, but the launching has been a success.

The Ten-Spined Stickleback (*Pygosteus pungitius*), otherwise known as the Tinker, has seven to twelve low spines and does not exceed three inches in length. It does not extend so far south as the Three-Spined species, and its northern limits in Scotland seem to be the Forth and Loch Lomond. It is more consistently a freshwater fish; the male is dark brown at the breeding season; the nest is not fastened to the bottom, but to water-weeds.

The Fifteen-Spined Stickleback (*Spinachia spinachia*) is large compared with the others, being five to seven inches in length. It is exclusively marine and builds a nest in

shore-pools. The materials are seaweeds and zoophytes, bound together by the delicate threads exuded from the kidneys. This is very like an abnormal condition becoming normalised, for if the kidneys of any other animal were to begin producing this mucous secretion we should certainly call it a disease. It is confined to the breeding season and to the male. We cannot help wondering if the males do really recover; we should like to know more about them. According to some authorities, sticklebacks spawn only once in their lifetime, and do not live more than two or three years altogether. It is worth considering whether the female's apparent indifference may not mean that she is fatally spent by the spawning, while the male, with less parental sacrifice and perhaps a tougher constitution, lives on and takes charge of the eggs and the young. Inquiry should be made, however, to discover whether he does not succumb to his labours.

There are many other interesting features of stickleback life, and it is certain that they would repay further study. They are among the few fishes that can swim by means of pectoral fins, which are usually balancing organs. The marine stickleback may be seen moving head-foremost or tail-foremost, rowing gently with its pectoral fins; but when it is in a hurry it exhibits the usual wavy movements of the posterior body—the orthodox method of swimming among fishes. Then there are the rapid respiratory movements of the mouth and gill-cover, sometimes 150 per minute, as if the little creatures were panting. Of interest also are the experiments showing that sticklebacks kept on white tiles become bleached, and that if the exposure has been prolonged they have some difficulty in recovering themselves when restored to a normal environment. There is a great deal to be found out in regard to sticklebacks.

THE HERRING

All fish is not the same fish; they differ in temperament as they do in taste. And one of the most marked individualities is the herring, so familiar in its various disguises

on the breakfast-table. Perhaps the herring has not much of an inner or mental life, but it is an alert creature with keen senses. Compared with easy-going fishes like the carp, it is nervous and high-strung. It is not easy to keep the herring in captivity, for it will dash itself against the sides of the aquarium or jerk itself clean out of the water on to the floor of the room. Thus it has been found impossible, we believe, to transport living adults to distant seas, such as those that wash the coasts of New Zealand.

One cannot rightly appreciate the herring without seeing it alive, which means an excursion on a fishing boat. To see the net drawn in is a feast to the eyes—the meshes seem to be full of broken rainbow. There is silver and gold, steel-blue and lustrous green, and hints of other colours. Many of the herring, caught by their gill-cover, are dead—drowned indeed—when the net is drawn in; but this is not true of all, and the live herring is unforgettable. Another feature that strikes us is the litheness of the body. As in other fishes of active habits, the portion of the body given over to locomotion is a very large fraction of the whole. It is well known that the paired fins of fishes are almost always balancing organs, and that the posterior half of the body, which is mainly sheer muscle, is the organ used in the rapid sculling by which most fishes swim. The herring's body is stiff indeed on the fishmonger's slab, but in the water it is even more than what Ruskin called "a twisted arrow." We cannot find any comparison save with some other consummately active creature, like a bird. The creature's stream-lines, so well adapted like those of a yacht, for swift movement through the water, are quite unsurpassable. Beauty of colouring, beauty of form, beauty of movement—we have them all in the herring!

When herrings play about in a shoal near the surface they "make a ripple," as the fishermen say, as if there were a slight breeze; and the sound of their going can be heard for a short distance when everything else is still. Their movements in the darkness are marked by bright light, which many fishermen and some naturalists believe to be due to the herring itself. For our part, we do not think that the

herring has any luminescence of its own. The light is surely due either to reflection, or to contact with small open-water animals, many of which are " phosphorescent." The glowing light seen on herrings hung up to dry is, of course, produced by luminiscent bacteria.

There are over fifty different species of the herring genus ; and of *the* herring of the North Sea and the North Atlantic there are several *races*, which are as much disputed about as the races of mankind. The herring, like man, is diffusive, exploring every niche of opportunity, and in various quarters of the fenceless sea different varieties or races have established themselves. Thus the dwarfish Baltic herring are very different from the splendid fish from the West of Scotland, which are sometimes over a foot long. But they are all fertile with one another, just like human races ; and as they are given to wandering, there have arisen baffling racial mixtures, just as in mankind. But there seems to be a well-marked distinction in certain cases, for instance between the " summer spawners " of the open sea and the " autumn spawners," which keep nearer shore. Those Rip van Winkles who do not believe in evolution should study the splitting up of the genus Herring or Clupea into species (like herring, sprat, pilchard or sardine, and shad), and the splitting up of the herring species (*Clupea harengus*) into its sub-species or races. Evolution is going on.

Herrings have no armour or weapons ; they have a multitude of enemies who enjoy their palatability—cod and coalfish, shark and rorqual, seal and cormorant ; they have no great equipment of brains ; *how, then, do they hold their own in the struggle for existence ?* Part of the answer may be found in their alertness and swiftness, but a great part is to be found in their capacity for prolific multiplication. They succeed not because they are strong or clever, but because they are many. A female herring may produce 20,000 to 40,000 eggs—not very many as compared with cod and conger, which run to millions, but enough. There is a considerable margin for safety. Moreover, the eggs do not float, like those of most of our food-fishes ; they sink when they are liberated, and they are glued to stones and the like on the floor of the sea.

There is great excitement at the spawning time, when shoals of herring seek shallower and sometimes less briny waters. Gregarious in its feeding habits, the herring is gregarious likewise in its multiplying. In a frenzy, lasting for five or six hours, the females liberate their ova, and the males the fertilising milt. The sea becomes greyish and a rank smell of herring rises from the surface.

Enormous crowds of young herring often frequent inshore and estuarine waters, where food is abundant; and these furnish a great part of the toothsome dish known as "white-bait." Of course that sometimes includes, very naturally, young fishes belonging to other species, *e.g.*, sprat; and there is a well-known tale of one of the British Museum ichthyologists who distinguished eight species on his dinner plate! The herring is a dainty feeder, depending mainly on small open-sea crustaceans—hence the delicious flesh. It is a gregarious creature, fond of company. It is intensely alive, and sometimes leaps into the air. Following its food, it roves far and wide, and up and down; it also "migrates" in search of suitable spawning ground, or because of many enemies, or because the waters have become oily and foul. The herring is a nomad and one of the most successful of fishes. We wish we knew it more intimately.

FLYING FISHES

On a voyage to the Cape or India or even America, it is no uncommon sight to see flying-fishes rising in front of the steamship's bows and skimming to either side high above the waves. Now and again one of them lands on the deck or dashes in at a port-hole. In some cases there is a swarm of these beautiful creatures, reminding us of insects rising in front of us when we walk in a meadow in a warm country like Italy. When the sun shines on them they look like big dragon-flies, and there is much point in what Ibanez says in his novel, *Mare Nostrum* (Our Sea): "Before the prow hissed the silken wings of flying fish, spread out in swarms like little squadrons of diminutive aeroplanes."

After much discussion most naturalists have come to the

conclusion that in the ordinary Flying Fishes of the sea (Exocœtus and Dactylopterus) the enlarged fore-fins serve as *parachutes* not as wings. They may vibrate a little in the first case, and flutter a little in the second, but they do not in the strict sense strike the air. The impetus is due to strong strokes of the tail before the fish leaves the water, and it may be increased by the force of wind and wave. When the fishes sink to the surface of the water again, they may lash out afresh with the tail and make another start without the body being immersed. They may repeat this performance at short intervals. It should be noted that the muscles of the pectoral fins, though somewhat more developed than usual, are not very strong, and that in ordinary fishes the paired fins are not for swimming but for balancing the body.

Some recent observations by Dr. E. H. Hankin throw a fresh light on the aerial locomotion of Flying Fishes. Much depends on the atmospheric conditions. In the Arabian Sea on a very still evening after sunset he noticed that the Flying Fishes did not glide in the air for more than a yard. They were also very liable to lateral instability or side-slip. On other occasions when there was sunshine and a light breeze the flight extended for 200–400 yards. As with " sailing " birds, a breeze is essential for successful " flight." The fore-fins are usually held " flat," that is, in a horizontal plane. Sometimes they are slightly inclined upwards. Now the soaring vulture has its wings in the " up " position for slow-speed flight and in the " flat " position for high-speed. In rare cases the fish had its fore-fins inclined very slightly downwards, and this " down " position is probably used for flight at the highest speed. It will be remembered that by " sailing " or " soaring " in birds is meant that mysterious kind of flight in which there is rapid progression without any apparent strokes of the wings.

Dr. Hankin also noticed that the extreme tips of the fore-fins may be bent up at an angle of forty-five degrees to the rest of the fin, and the same appearance is seen in the wing-tips of vultures in their horizontal sailing flight. This is another fact pointing to the conclusion that the " flight " of the Flying Fish has something in common with the

"sailing" or "soaring" of albatross and vulture. There may be flapping of the fore-fins at the start, but not after the fish has got well under way. A speed of over ten yards per second was observed, the fish keeping up with the vessel for eight seconds. The maximum rate is probably about twenty yards per second.

By careful observation of species of flying fish that have coloured hind-fins, Dr. Hankin was able to show how the fish checks its velocity both in high-speed and low-speed flight by altering the position of these fins.

In one species that has the hind-fins small and far forward, therefore unsuitable for checking speed or for vertical steering the fore-fins are drawn back through an angle of about forty-five degrees when the fish reaches the end of its flight. The result of this is that the fish makes a nose-dive into the water without altering its speed.

SEA-HORSES

In the early days of Natural History the discoverer of a strange animal in the sea had to face the difficulty that he could not get his friends to believe his story. One way of winning conviction was to produce the specimen, but that was not always easy. Another method was to submit a drawing. Another method was to say: "After all, what I saw is not so incredible; it was simply the sea's counterpart of what you are familiar with on land." Thus grew up the notion that there were marine "doubles" of many of the terrestrial types. This is seen in many of the names given to sea animals in many different languages—sea-anemones, sea-butterflies, sea-cucumbers, sea-devils, sea-eagles, sea-fans, sea-gulls, sea-horses—and so on down to sea-urchins and further.

The sea-horse (Hippocampus) is one of those animals that provoke a smile. It borders on the ridiculous—with the head of a horse and the prehensile tail of a monkey. Dr. Theodore Gill compared it to a knight on the chess-board mounted on the dainty coiled shell of the little cuttlefish called Spirula; and the second half of the technical

name Hippocampus is Greek for a curled-up caterpillar or worm.

Ordinary fishes move their body from side to side, jerking out masses of water to right and left; but the sea-horses have a very stiff bucklered body and their coiled tail moves up and down like a chamæleon's. Another element in their quaintness is the independent movement of the two eyes, a peculiarity which is also exhibited by the lizard we have just mentioned. That in itself is a curious point.

Sea-horses are widely represented by various kinds in most warm and temperate seas, and they are familiar, though fastidious, inmates of aquaria. It is a great pleasure to watch their quaint movements, which are never hurried. There seems to be an adjustment of the gas in the swim-bladder to the specific gravity of the sea-water, so that the sea-horse requires little or no effort to keep afloat. A favourite resting pose is bolt upright, with the tail coiled round a stalk of seaweed.

Sometimes the creature sinks slowly downwards as if on a hinge. Then it lets go and moves in the water by the extremely rapid undulatory movements of the single dorsal fin, helped by the quick strokes of the delicate paired pectorals. It always tends to fall forwards in the water, but quickly recovers itself, and is vertical once more. The movements are too slow for hunting purposes, and we believe that the sea-horse uses its little mouth in a somewhat pipette-like fashion to suck up young crustaceans and other small fry from the fronds of the seaweed or from the sub-stratum. Excepting those kinds that live among floating seaweed in the open ocean, the sea-horses are at home in well-illumined, seaweed-bearing, relatively shallow in-shore waters.

A careful observer has noticed that sea-horses make at intervals " a sharp little snapping noise," which seems to be produced by very rapid quivering movements associated with opening and shutting the lower jaw. They must not be thought of as chattering, for the sound in our British species is slender and monotonous; but it is interesting to know that one sea-horse answers another, that the sounds

are made by both sexes, and that they are more frequent and intense at the breeding season. It is comical, somehow, to think of the delicate " neighing " of the sea-horse. But we must turn to something much more remarkable than conversation.

On the under-side of the front of the male's tail there is a capacious pocket. It is formed by the fusion of two folds

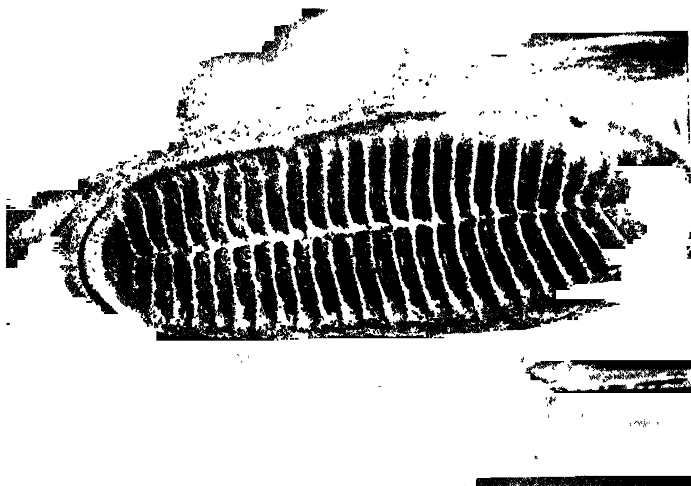


Photo: W. S. Berridge, F.Z.S.

SUCKING APPARATUS ON HEAD OF THE REMORA.

This remarkable adhesive organ, by means of which the Remora fastens itself, seems to be developed by a transformation of the first dorsal fin. It consists, as the photograph very clearly shows, of a number of transverse plates, which are pressed against the skin of the victim, and secure adhesion.

of skin and has an anterior opening. Into this opening the female presses a few eggs at a time and it is apparently in the course of the transfer that they are fertilised by the male. After a short time the female comes back again to lay more eggs in her partner's pocket! What is more, several females may take advantage of one male. All this is very quaint.

The eggs develop in the water-tight pocket and they

seem to be fixed and partly nourished by the spongy internal lining, which becomes very rich in blood-vessels. As is usual in fish eggs, there is a considerable amount of yolk which is gradually used up as development goes on.

After a while the minute sea-horses have taken shape and become restless within their cradle. The father-fish presses his monkeyish tail up against his pocket, and a few young ones are expelled at the anterior opening which has begun to gape. Or it may be that he presses the pocket against a winkle-shell and thus secures the expulsion of the fry. This is a very strange occurrence, for it looks as if the male fish was giving birth to young ones. According to one observer, each effort is followed by a few minutes' rest, three to six youngsters are set free at a time, and the whole business may last for about six hours.

The newly liberated young ones swim away and are lost among the seaweed. In the common Mediterranean sea-horse they are towards half an inch long, and are like miniatures of the parent except that the big scales have not developed and the snout is relatively shorter.

Many of the sea-horses are coloured like the seaweeds among which they live, and the Zostera sea-horse that frequents the sea-grass (a flowering plant) on the Florida Coast has a very inconspicuous dress of mottled olive-green.

But protective resemblance reaches a climax in the Australian Phyllopteryx in which the spines and knobs of the head and body are drawn out into frond-like tags, often branched and wavy. Never was there a more betasselled horse! This form is also interesting from an evolution point of view, for the pouch is represented by a groove underneath the tail, a condition seen also in some of the pipe-fishes, which are not very distant relatives of the sea-horses.

What one would most like to understand is why the parental care is *paternal*, especially as the males are smaller than the females. One can understand that parental care is highly advantageous, but why such emphatic division of labour should have been insisted on is beyond us at present.

THE PLAICE

On the British list of practically important food-fishes the laterally flattened plaice occupies a prominent position. It is not nearly so abundant as the haddock or the herring, and it is not cured; but it is a general favourite, and it is very nutritious. It is a near relative of dab and flounder, but it grows larger and plumper, and is far more important commercially. It commonly weighs two or three pounds, but often more. In favourable circumstances, where it is not greatly harried and where food is abundant, it grows on and on, and becomes a giant. For it must be remembered that few fishes show the definite limit of growth familiar in most animals. A lucky haddock may grow to be as large as an average cod, say three feet long.

The adult plaice is fond of lying on a sandy bottom in shallowish water, and its up-turned side, usually olive-brown with orange spots, changes in colour in harmony with that of the immediate surroundings. Like its relatives, the other bony flat-fishes, the plaice can put on a cloak of invisibility, the change depending on the contraction and expansion of the irregularly shaped pigment-cells of the skin. But the plaice does not need this protection when it is resting, for its body is mostly covered with a thin layer of sand, and only the watchful eyes protrude. The plaice keeps a sharp look-out for molluscs, crustaceans, and worms; it is a very clean feeder, and that is probably one reason why it is so palatable. Like most of its relatives, excepting brill, megrim, and turbot, the plaice rests and swims on its *left* side; and every one knows that the down-turned surface is silvery and without any pigment. The silveriness is due to the reflection of light from minute spangles of a waste-product called guanin, which accumulates in certain skin-cells called iridocytes. The originally left eye travels round till it lies beside the other on the right-hand side. Otherwise it would get scratched; moreover, it comes to lie where it is of most use. But the travelling round is very remarkable.

Plaice spawn in the early months of the year, when the temperature of the water is at its lowest. The eggs are shed and fertilised in the upper layers of the water, but they tend to sink as development goes on. They are about one-twelfth of an inch in diameter, so that about a fifth of a million might be contained in a fluid quart. The spawning is in a way very discriminate, for it is practically restricted to the area between the shallow-water zone and the 30-fathom contour-line. According to recent investigations, the suitability of a sea-area for spawning depends, not on the depth, nor on the salinity, nor on the proximity to the land, if we consider these conditions by themselves, but rather on the temperature of the water and on the formation of eddies. These great eddies are no doubt connected with the configuration of the coast and the lie of the sea-floor. They are well known in all the great spawning grounds, namely, the " Flemish Bight," the " East of Dogger " area, the " Flamborough Off " area, and the Moray Firth. We must put the well-known Scottish area last, for, while it is the most important plaice-nursery for Scottish waters, its contribution to the total North Sea plaice population is small in comparison with that from the southern spawning grounds.

Inside the egg-membrane the development of the larva goes on for about twenty days, and during this period the floating eggs are to some extent dispersed by currents. Thus some of those liberated in the Moray Firth seem to be carried eastwards and southwards, and probably go to stock inshore waters on the East of Scotland, south of Rattray Head.

First there is the spawning, secondly the development within the egg, and, thirdly, there is the hatching. There emerge the larvæ—about two-sevenths of an inch in length—which exhibit occasional jerky movements, but for the most part drift passively. Each is encumbered with a legacy of yolk, on which it depends for food, for a few days entirely, and for a few more days partially. When the larva is about four days old it opens its mouth and begins to steer its course. It feeds on floating miscroscopic plants



Photo: Neville Kingston.

INDIAN GOURAMI (*Osphromenus olfax*).

This Malayan freshwater fish, acclimatised in India, the Guianas and Mauritius, is famous for the bubble nest that the male constructs and guards. It is made of air bubbles entangled in a mucous secretion from the mouth. The fish itself may grow to be two feet long, and is very palatable.

called diatoms and on other larvæ; and it passes through a very critical week, on till the twelfth day or so, when the yolk is entirely used up and the "post-larva" becomes a "fry." It is important to notice that this "fry" is shaped just like a young "round fish," such as a haddock. It swims vertically, with its dorsal middle line up to the sky. Entirely dependent on its own resources, it runs great risks, and the more energetic it is in seeking for food, the more

likely it is to attract the attention of hungry enemies. There is great mortality.

Egg, embryo, larva, post-larva, fry—these are the five chapters of the first month in the life-history of the plaice. But the sixth chapter is the strangest of all. It is the time of the great change or "metamorphosis," the transformation from a miniature "round fish" to a miniature "flat fish." The left eye moves to the right side; the skull becomes strangely unsymmetrical; the body is flattened from side to side—just the opposite of the skate's flattening, which is from above downwards. The young plaice, about three-fifths of an inch in length, sinks to the bottom, and henceforth rests and swims on its left side, which must be the heavier. We have already noticed that the pigment-cells become restricted to the up-turned side, which is more under the influence of light. Experiments have proved that light is needed if the pigment is to develop; and when light was thrown up for four months from a mirror on the floor of an aquarium, where young flounders were sinking downwards and changing their shape, ten out of thirteen developed yellow and dark spots on the down-turned side, which is normally without pigment.

If the metamorphosis is safely accomplished the young plaice probably gets a firmer foothold in the struggle for existence, if we can speak of a fish having a foothold. It is more of a free agent than in preceding phases; it has passed from the surface to the floor; and it has a readily available refuge in the sand, where it devours small crustaceans and the like. But it seems to be a restless creature—obedient to the almost universal urge after greater satisfaction. It feels its way from the spawning areas to the inshore nurseries, even between tide-marks. It grows to a length of about three and a half inches by the end of its first summer. The tendency of the growing plaice is to seek deeper water in the winter, and as it grows older it lives farther from the shore as long as it can find plenty of young cockles and mussels, which form its staple food. On an average the males are mature at the end of their fourth summer and the females a year later; but their size at maturity varies

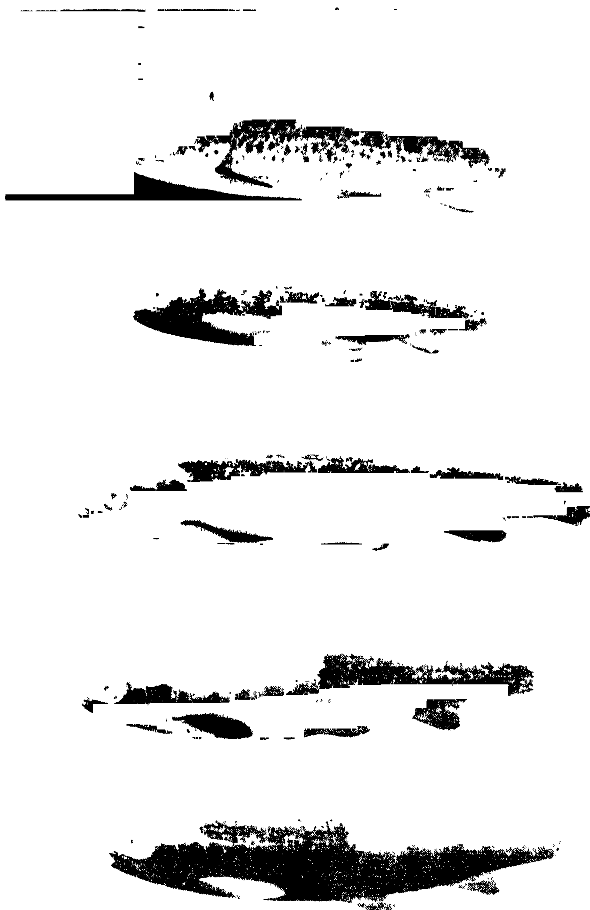


Photo: J. Arthur Hutton.

A trout at the top, then a parr with n arks, and then three smolts. The scales have been partly removed from the two lower smolts, to show the darker parr colouring underneath the scales. A smolt is a young salmon about to go down to the sea or on its way. Its silvery sea-jacket masks the parr markings. See *The Life-History of the Salmon* (1925), by Mr. J. Arthur Hutton, to whom we are greatly indebted for the photographs.

with their opportunities for food and with the depth of the water. It must be kept in mind that the full-grown plaice is a good deal of a rover, passing from region to region, always in search of the better.

It is computed that a very large female plaice may contain half a million eggs, and an ordinary six-year-old fish over a quarter of that number. This illustrates Nature's way of working with a large margin. But the chances of death are enormous! Many eggs probably die unfertilised, and many are devoured at the very start. Some are drifted into unsuitable places. There is great mortality during early development, especially perhaps at the critical time when the larva is beginning to fend for itself. The great change from the "round fish" to the "flat fish" type is another crisis. Then there are fluctuations in the supply of the molluscs and crustaceans on which the plaice depends for sustenance. There is no doubt that there must be keen competition among the plaice themselves when an area becomes overcrowded, and the multiplication of fishes outruns that of the backboneless animals on which they feed. Moreover, the plaice is too palatable a fish not to have many hungry enemies all through its life. Finally, more than any other fish, perhaps, the plaice shows in its fluctuations of abundance and of size the influence of man. Before the war, experience pointed to the conclusion that the fishermen—the trawlermen in particular—were taking too many plaice out of the North Sea. Good-sized plaice were becoming less and less abundant in the catches. But when fishing was resumed after the war, "the catch per day's absence" increased in a very striking way. As against 2·1 cwt. in 1913, it was 4·5 cwt. in 1919; and there was a considerable increase in the numbers of large and medium-sized plaice, far outweighing an actual decrease in the numbers of small fishes. In what precise way the stoppage of the fishing during the war brought about this result is a question not to be answered lightly, but the general fact that the fishery was greatly improved by the "rest" is clear. But the improvement did not last, and the very important practical problem is how to keep up the supply

of this very valuable and palatable food-fish. There are two main suggestions. One is that millions of young plaice should be transplanted from abundantly peopled coastal grounds to suitable feeding areas like the Dogger Bank. The other is that certain areas, where young plaice abound and grow rapidly, should be closed to certain kinds of fishing for the whole or for part of the year. Man always tends to be shortsightedly greedy, killing the goose that lays the golden eggs.

THE SKATE

In contrast to an open-sea fish like the herring we wish to take one from the floor of the sea, and none could be more characteristic than the skate. Before bone develops in an individual backboned animal there is a stage with gristle or cartilage ; and before any bony fishes appeared in the seas there were antique forms with skeletons of gristle. At this level skates and sharks still linger ; they have no bone except in their teeth and their scales. In this respect, and in some others, skates are primitive, but while the race of fishes is represented in Ordovician rocks, dating from some hundreds of millions of years ago, it was not till Jurassic times, when birds first appeared, that there were well-defined sharks and skates.

As happened very often in the course of evolution, there was a divergence of active and sluggish types. The sharks and dog-fishes became the active bullies of the upper waters ; the skates and rays represent the outcome of a more sluggish mode of life on the floor of the sea.

There was a flattening out of the body from above downwards, and an enormous expansion of the fore-fins. A skate swims by undulating its pectoral fins, but these are mere balancing structures in a shark, which swims by lateral strokes of the posterior region. The flattening out of the skate's body brought the mouth to the ventral surface, so the creature has to get above the mollusc or crab or fish which it wishes to devour.

As locomotor functions have been shifted away from the tail region, it is not surprising to find that this has often been

turned into a weapon, as in the case of the sting-rays, where it may be six feet long and carry a serrated dagger of as many inches. It will be understood that the gristly skates are not related in any way to the bony flat fishes, like halibut, plaice, and sole, which rest and swim on their left side, or else, as in brill and turbot, have the right side downwards. While the lie of the body is utterly different in skate and halibut, it is an interesting zoological puzzle that both types have the two eyes on the upturned surface.

True skates are usually found in relatively shallow water, where there is abundant animal life on the sea-floor. They may reach an enormous size, occasionally over six feet long, not counting the tail. They are probably protected in some measure by their sharp-pointed scales, or skin-teeth, which show a curious combination of three kinds of hard tissue. They are tipped with enamel, based in bone, and cored in ivory or dentine. In our common smooth skate or barn-door skate (*Raia batis*) the skin of the adult fish is almost without spines, but there are plenty of them on the young forms—an illustration of the usual tendency of youth to be nearer the ancestral type. Another point of evolutionary interest is the presence of a small electric organ on each side of the tail in some species of skate. These seem to be structures in process of evolution, which have not advanced far enough to give a paralysing shock. They are transformations of muscle-fibres and nerve-endings, and are like initial stages of the powerful batteries possessed by electric eels and the Torpedo.

Behind a skate's eyes there are two large openings into which one can thrust a finger. These are called the spiracles, and they serve for the inflow of the water used in breathing, which passes out again by five pairs of gill-clefts on the ventral surface behind the mouth. In point of fact the spiracles represent the first pair of gill-clefts turned dorsally, and by one of those strange transformations that make comparative anatomy so fascinating, they are represented in our body by the Eustachian tubes, which establish communication between the ear passages and the back of the mouth. When we peer into a skate's spiracle we see a small

comb-like structure, and this is a dwindling remnant of a gill. It is a good example of a useless vestigial organ, like an unsounded letter in a word, as Darwin said, or like one of the unusable buttons or buttonholes on a jacket. It is of no use, but it is a historical record. Hidden at its base is a peculiar cushion, which seems to help a little in keeping up the supply of red blood corpuscles. This is of use, and the aperture is of use, but the gill itself is a mere relic.

On the under surface of a skate we see a large number of twisted jelly-tubes, embedded in the skin and ending in pin-head apertures. There are a few on the dorsal surface, especially on the head. These are sensory tubes, but it is not certain what sense they represent. Perhaps they make the fish aware of movements in the water, perhaps they are sensitive to changes of pressure, perhaps they help the fish to keep its balance in swimming. They correspond to the lateral line in Bony Fishes, but they remain physiological puzzles. Here it should be noted that the skate's brain is at a much higher level than that of any bony fish ; and while the smelling and locomotor-control regions are particularly well developed, there is probably a glimmer of intelligence. A skate has been known to display what looked like cleverness in " trying to escape " from a trawl that was being dragged behind the vessel.

" The Mermaid's Purse " is a fanciful name for the horny shell formed round the egg of a skate or dogfish. It is a four-cornered purse, sometimes called a " shark-barrow " from its resemblance to the hand-barrow which two masons use in carrying a heavy stone. In dogfishes the purse has each corner drawn out into a long tendril which coils automatically around a frond of seaweed or a zoophyte stem, thus anchoring the egg. In skates there are no tendrils, only pointed corners, and the egg seems to be buried in the débris on the sea-floor. The size of the purse depends on the species and age of the skate ; we have one that is eight inches long, and this is certainly not the maximum. But a common length is about five inches.

The development of the skate's egg is very slow, taking sometimes more than six months, and thus there is the

greater need for a protective egg-case. When the young skate is fully formed and has exhausted its legacy of yolk, a change occurs in the white of egg, and a slit is formed by solution at one end. Through this the young skate makes its way out, but our knowledge of these matters is very scanty. The purse is made of the same material as our finger-nails (keratin), and we have seen it being formed round the egg (in an oviduct-gland) by the coalescence of multitudinous viscid threads of fluid horn. The mermaids' purses that are found among the jetsam on the seashore almost always have one end gaping, which indicates, of course, that the young skate has hatched out. To get a purse with a young skate inside is great good luck.

XXI

THE WAYS OF MOLLUSCS

THERE have been three *very* successful lines of animal evolution: (1) that of JOINTED-FOOTED ANIMALS or ARTHROPODS, with their climax in ants and bees, spiders and scorpions, crabs and lobsters; (2) that of MOLLUSCS, with their climax in cuttlefishes and snails; and (3) that of BACKBONED ANIMALS or VETREBRATES, with their climax in birds and mammals. These three lines of evolution are very different from one another, expressing, as it were, different ideas. The Jointed-Footed Animals or Arthropods have ringed or segmented bodies with many limbs or appendages; they have an outside non-living skeleton made mainly of a very resistant material called chitin, to which lime is added in crabs and lobsters and the other Crustaceans; this outside covering (or cuticle) has to be periodically moulted as long as the growth of the body goes on, for it cannot grow itself, being without living cells; and the limbs have the muscles inside the skeleton, not outside, as in backboned animals. The Molluscs have no limbs at all; the body is not ringed; their shell is usually rigid, composed of lime and a material called conchin; and it does not require to be moulted, for additions are always being made to the free edge as the animal inside continues to grow. The Vertebrates may have an outside skeleton, such as the scales of fishes and reptiles, but this may be absent, and, in all ordinary cases, it is unimportant compared with the internal skeleton—the skull, the backbone and ribs, the limbs, and their supporting girdles. In most cases this inside skeleton consists of bone, which neve occurs among Invertebrates. The limbs are limited to twc pairs; and there are many other important characteristics, such as the dorsal brain and spinal cord.

The group of Molluscs includes: (1) Bivalves, like cockles and mussels, oysters and clams; (2) Gastropods, like land snails and slugs, whelks and periwinkles; and (3) the Cephalopods, including the cuttlefishes and Nautilus. On the whole, they are slow-going creatures, with a great deal of slowly-contracting or unstriped muscle, such as occurs on the wall of our food-canal. Although cuttlefishes, slugs, and sea-butterflies have practically no shell, most of the molluscs are weighted with very substantial encasements. The Giant Clam or Tridacna is often too heavy for a man to lift, and a single valve makes a big bath for a baby. Naturally enough, then, many molluscs are very sluggish. Oysters and mussels are practically sedentary after their juvenile free-swimming stage is past; a limpet makes only short excursions on the shore-rocks in search of palatable seaweed; and the beautiful Pearly Nautilus, though sometimes seen at the surface, usually lives sluggishly on the floor of the sea, at depths of 300 to 600 feet. But the sluggishness which is the rule is not without its exceptions. The dainty "sea-butterflies," which form a great part of the food of whalebone whales, are free-swimming, open-sea Gastropods. The common scallop (Pecten) swims by clapping its two valves, and there is a beautiful bivalve called Lima, not uncommon in the Firth of Clyde for instance, which swims now and then at a good rate, with orange-coloured tentacles streaming out behind. It is interesting also since it lives habitually on the sea-bottom, inside a nest made of pebbles and mud loosely glued together.

But it is among modern cuttlefishes or Cephalopods that we find the most remarkable emancipation from the sluggishness which must be regarded as fundamentally characteristic of Molluscs. Many of the cuttlefishes (squids especially) swim as rapidly as fishes, and the shape of the body when swimming is sometimes remarkably fish-like. Of course the word cuttlefish is a mere popular name, for Cephalopods are not in the remotest way related to true fishes. But the point is that out of a sluggish race there have evolved, with gradual suppression of the shell, very active forms like squids—molluscs that can actually catch fishes!

An ordinary squid (*e.g.*, Loligo) has three ways of moving. It can creep along by means of its tentacles or arms, which bear numerous gripping suckers. Two of these arms are much longer than the other eight, and can be shot out to catch a passing fish, as Aristotle noticed more than two thousand years ago. Secondly, the squid can swim head-foremost, moving in the water by means of the muscular triangular fins at the posterior end of the strangely shaped body. Thirdly, there is a kind of locomotion peculiar to cuttlefishes, the effectiveness of which has to be seen to be believed. Behind the head there is a wide opening leading into a spacious "mantle-cavity," where the two gills lie. When this cavity is full of water the aperture is quickly and neatly closed by a remarkable hook-and-eye arrangement. The mantle or outer wall of the cavity is then contracted, and the water, which cannot go out where it came in, is forced through a narrow outlet, called the funnel. This gush of water, rhythmically repeated, drives the squid along, with the posterior tip of the body in front, and the arms pressed together behind. The triangular fins, which are leading in this quaint kind of locomotion, quite unique in the animal kingdom, seem to be used in steering. The swimming is helped in the squids and in Sepia by an interesting *internal* vestige of the external shell, within which the ancestors of modern cuttlefishes were wont to live. In Sepia this relic is a fairly substantial wedge of spongy lime, the "Sepia-bone" or "Sepiostaire," which is given to cage-birds to peck at. In the squid the relic is a long, chitinous blade or "pen," a little like an old-fashioned quill. In both the vestigial "shell" is quite hidden, but serves as a sort of axis, which consolidates the body in swimming. In the less active Octopus, there is no vestige at all, except that the embryo, as in all Molluscs, has a transient microscopic shell.

Relinquishing a shell, as the cuttlefishes have done, means the possibility of greater freedom, but it involves the exposure of the body to assault. Thus we look for compensations, and we find them in the sucker-bearing arms or tentacles, which are often very formidable weapons.

In the case of a big Octopus or other "Devil-Fish," they may be dangerous to man himself. The perfect sucker is somewhat cup-like, with a marginal ring of chitin furnished with gripping teeth; there is an internal piston which is raised when the sucker is pressed against the skin of the

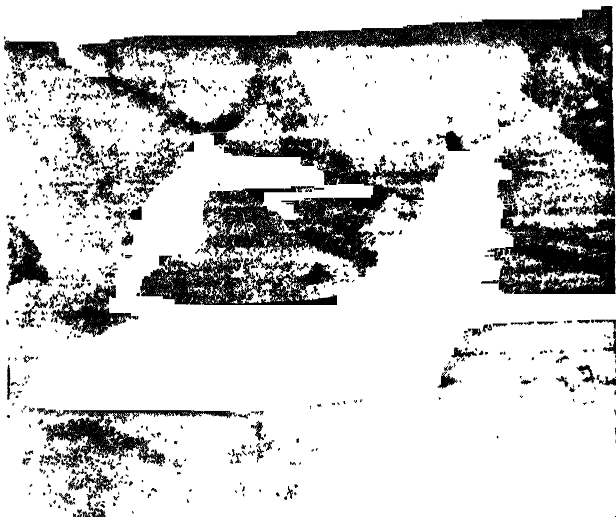


Photo: W. S. Berridge, F.Z.S.

BLACK SLUG (*Arion ater*).

This handsome animal may grow to be four inches long, and varies from the normal black to brown and red and other colours. Although characteristically vegetarian, it often eats animal matter. The shell is reduced to a few granules of lime on the back.

victim; this raising produces a partial vacuum and the grip is very tenacious. The marks of huge suckers, as big as tumblers, are sometimes seen on the skin of a whale.

There may also be some value in the remarkable power of colour-change which cuttlefishes often exhibit. The octopus is often well adjusted to the corner among the rocks where it lurks. In other cases the colour alters according as the animal is pleased or displeased. As in fishes, the

change of colour is due to the contraction or expansion of the numerous pigment-cells (chromatophores) in the skin.

Noteworthy also are the very strong jaws, closely resembling the beak of a parrot; and their efficiency is increased by the poisonous secretion of the posterior pair of salivary glands opening into the mouth.

But there is a unique protection in the power of discharging ink, a quaint way of throwing dust in the eyes of assailants! The sepia ink, which was formerly used by painters, is a waste product which accumulates in a bag at the end of the food-canal. Its discharge is due to an automatic (reflex) contraction in moments of excitement. It can be seen in a very young cuttlefish a minute after it escapes from the egg envelope, thus illustrating what is meant by an inborn reaction, like our ability to sneeze. In natural conditions when the cuttlefish is in danger it may escape in a cloud of ink, which acts like a smoke-screen in naval warfare, save that it is under water. We see, then, that modern cuttlefishes have many compensations for the loss of the shell.

Many of the cuttlefishes, such as squids, liberate their eggs in gelatinous tubes, which are fixed to seaweed; in other cases, such as octopuses, the eggs form a branched bunch and deserve their name of sea-grapes. The development is telescoped down, with an omission of the free-swimming larval stages which are usual among aquatic molluscs, and out of the egg envelope there comes a fully-formed miniature of the parent. We see the same sort of suppression of juvenile or larval stages in the land snails and slugs, but for a different reason. For a thoroughly terrestrial animal that lays its eggs in the soil could not have free-swimming larvæ.

To the question, why there should be no larval stages in cuttlefishes, it is more difficult to give an answer. The suppression has probably to do with the fact that the comparatively few eggs have a good deal of nutritive legacy in the form of yolk, and that risks are lessened by launching the offspring as fully-formed vigorous youngsters able to fend for themselves.

In the female Argonaut or Paper Nautilus, a cuttlefish of the Open Sea, two of the arms are expanded into webs, and secrete a fragile shell of great beauty, which is used as a cradle for the eggs and for the young.

The shell differs from that of the Pearly Nautilus in not being chambered, and in being not a house, but a cradle. It also differs from every other molluscan shell in being a product of two arms, and not of the mantle or skin-fold. Another peculiarity is that the shell is unrepresented in the male, who is a pigmy compared with his mate—not that she can be called big. The shell begins to be formed in the female while she is still very young, perhaps ten or twelve days old, and it is gradually added to as she grows. It will be understood that as the shell is non-living, it cannot grow of itself; it is added to by the arms. The old notion that the Argonaut raises her webbed arms to form a sail is entirely without foundation—notwithstanding poems and pictures to the contrary.

Cuttlefishes have a relatively large central nervous system of a molluscan type, and well-developed eyes which bear a striking superficial resemblance to the eyes of Vertebrates, though they are developed in a very different way. There are structures sensitive to smell and touch, and there are also ear-like organs which seem to help in balancing. But it is not possible to say much as yet in regard to the mind of cuttlefishes. They are effective in capturing their prey, and some of those that have been watched in aquaria have shown persistence and daring in the pursuit of what they wanted. The fact is that cuttlefishes are so well equipped for their ordinary life that instances of intelligence outside everyday efficiency are difficult to find.

We cannot turn away from this glimpse of cuttlefishes without noticing that they have been the foundation of some of the best sea-serpent stories. The arms of some kinds (Architeuthis) have been known to attain a length of forty feet, to which have to be added ten feet for the body and head. If this huge creature were to launch itself half out of the water, as cuttlefishes sometimes do, there would be the beginning of a very presentable sea-serpent. On the Irish

Coast a specimen was once caught with tentacles thirty feet long and eyes fifteen inches in diameter. Larger forms occur on the American coasts. A big piece of a scale-covered cuttlefish was obtained by the late Prince of Monaco from the stomach of a sperm-whale. As the kind of cuttlefish to which it belonged has not yet been found, we are warned not to be too dogmatic about what the sea does or does not contain. In any case, the cuttlefishes are among its masterpieces.

Several different kinds of Octopus are often to be found on the southern parts of the British coast. The body of the octopus is about the size of a coco-nut ; it is soft and yielding to the touch, and covered by a warty skin, which changes colour with extraordinary quickness, from a livid blue-grey to a speckled brown. Surrounding the mouth, and below the two unwinking eyes, are the eight arms or tentacles : sometimes a couple of feet long, tapering, whiplike, always restlessly curling, and armed all along their inner surfaces with rows of round suckers, closely set, varying from the size of a shilling to that of a threepenny bit. As the animal sits in a corner of a pool, with its arms all coiled under it in spirals, with the suckers outwards, the body throbs with a slow pulsation : when it swells, water is drawn in to wash the gills ; a moment later, with a strong contraction, it is forced out again through a small funnel set behind the head, often with force enough to stir the surface of the pool. This is a slow, heavy kind of breathing. There is nothing quite so terrifying as an octopus, not even the lurking spider or the venomous snake ; and stories of giant " devil-fish " furnish material for the most breathless of nightmares.

And now if some hapless crab chance to tumble into the pool within reach, one of the long arms is deliberately yet swiftly unwound and falls across the crab's smooth back, where the suckers take instant hold. No time for burrowing nor for striking attitudes of defiance ! Only too lucky if it can wrench itself away, the crab hurries as fast as it can, tumbling off stones, blundering against others, heedless of anything but escape. Slowly at first, and very smoothly, the octopus sets off in pursuit, crawling along on its eight

arms. If this is not fast enough, the octopus may start swimming—quite a different movement, for it swims backwards, with the arms trailing behind. It swims as it breathes, by forcing out a jet of water, and each stroke drives it six feet or more. As it touches bottom again, the eight arms are



Photo: M. H. Crawford.

GARDEN SNAIL, SHOWING REPAIRS TO BROKEN SHELL.

The garden snail (*Helix aspersa*), one of the most familiar of animals, the cause of many disappointments to the gardener. It wanders in a leisurely way for considerable distances, leaving a trail of mucus which marks its path, and often shows that it can return to its original starting-point.

smoothly and simultaneously coiled up as if into a pattern. In another moment the octopus will unfold upon the unhappy crab (which never appears to offer the slightest resistance), catching it with several arms at once, and with the largest suckers, which are at the base of the arms. Once truly caught, the crab has no chance of escape ; though the

octopus may, if it chooses, hold it a long time in its arms without beginning to eat it.

The common sea-shells, such as the limpet, the cowrie, and the clam are more nearly related to the octopus than one might at first suppose. In comparison, their lives seem to be uneventful and their movements sluggish ; and there are some, like the oyster and the mussel, which never move from the place where they first settle down. Many others only creep about like snails, but there are a few which are more vigorous : the razor-shell can burrow in the sand very quickly indeed, and can also swim a little in the same way as the octopus, by squirting out a jet of water ; the cockle and some others can take small jumps ; while others swim in quite a different way. The scallop, for instance, a big two-valved shell, not unlike the oyster, lies on the surface of the sand or gravel, with the two valves slightly apart, and when disturbed it usually replies by shutting the valves firmly together. But this is no protection against its arch-enemy, the starfish, from which the scallop always seeks safety in flight. When it feels the starfish's arm pass over it, it swims away, opening and shutting the two valves with quick flapping movements, and in this way steering an erratic course through the water. But it travels quite blindly, and often in a circle, so that it may come back to the very spot from which it started. If it finds the starfish still there, or if it lands on another one, it may start out again, but much less strongly ; and a third swim will exhaust it completely. Thereafter it has recourse to merely passive resistance ; it shuts the valves very tightly and holds on with all its strength.

But it seems strange that a starfish should be able to open a scallop, or an oyster, or a mussel. The octopus cannot do it, and yet it is far more muscular than the starfish ; and every one knows that an oyster is very difficult to open. How does the starfish manage ? The under surface of each of the starfish's arms is divided by a deep groove, running the whole length, from which are protruded the "tube-feet" : thin, flexible tubes, which can take hold of objects by suction, for example when the starfish climbs over rocks. They are not powerful sucking discs, like those of the

octopus, but they are very numerous. With these the starfish grasps the valves of the shell. It raises its body into a hump, and stands on the tips of its five arms, so that it is able to grip the shell with all five at once, and to pull from both sides simultaneously. Now, although a mussel or an oyster or a scallop can resist a very strong pull for a short time, it cannot long resist a steady, continuous strain; so that in the long run the starfish manages to pull the valves apart, thus exposing the soft-bodied mollusc inside. The starfish has a very elastic stomach, which it can squeeze out through its mouth so as to envelop its prey; and in this way the soft flesh of the victim is completely digested.

In the large class of bivalves—cockles and mussels, oysters and clams—the head region is undeveloped and the nervous system is of a low order, with little centralisation. They are mostly sluggish as regards locomotion, and live an unadventurous life, shut up in their shells. The cockle sometimes makes little jumps along the sand, and the freshwater mussel ploughs its leisurely furrow in the mud of the river. No doubt all bivalves do a prodigious amount of *internal* work, for the living lashes, present in thousands on the gills and lips and skin-folds, keep up currents of water which carry in oxygen and microscopic food and sweep out waste. But the *external* work is slight.

When a freshwater mussel keeps its young ones in the cradle of its gills and does not let them escape until a minnow or some other fish comes swimming past, it is doing a very effective thing, for the young ones cannot grow up without sojourning for a time on the minnow or some similar bearer. But no one would dream of calling the mother-mussel intelligent. It is constitutionally so built that it retains its young ones till the passing fish unconsciously gives the signal. The fish is the key that opens the door, but the mussel does not *think* about it.

An oyster sometimes closes its valves tightly on an intrusive starfish, and cases are known of an inquisitive rat being caught in this way at very low tide, but it is safe to say that the oyster did not *mean* to do it. It was a reflex, not a reflective action. " Learning " is perhaps beginning

when oysters that are being artificially reared become accustomed to longer and longer periods of exposure out of water. They keep their shells shut, retaining enough water to be going on with. This is a profitable thing to do, and the fitness of it is not contradicted by the fact that the oyster-farmers on the French Coast lengthen out the period till the oysters keep their valves closed all the way to Paris.

It has been shown that limpets on the seashore rocks sometimes return to their particular corner after they have been on an excursion after food. The advantage of returning to a particular spot is plain in those cases where the margin of the limpet's conical shell fits the surface of the rock with precision, and thus enables the animal to retain water when the tide goes out. When the rock has a more or less flat and uniformly smooth surface, the advantage of returning to a particular spot or " scar " is not so great. Perhaps this may explain why some limpets do not seem to show any " homing " tendency. Among those that " home " it has been noticed that the distance from which they can regain their " scar " is limited to a few inches. On the other hand, one retentive individual seemed to " know its way home " from a distance of four inches after the interval of a fortnight. The probability is that the limpet builds up a topographical memory of the immediate surroundings of its own particular " scar."

It appears to be well-established that a garden snail can find its way home from a distance of six yards. Of one that habitually spent the day in a hole in a garden wall, it is recorded that it continued for months utilising as a nocturnal ladder a piece of wood sloping from a bed of herbs to near the hole. Perhaps it followed its own trail.

Darwin mentions in *The Descent of Man* the case of two Roman or Edible Snails, one sickly and the other vigorous, which were placed in a garden ill-provided from the snail's point of view. The vigorous one went over the wall and found abundance next door. After twenty-four hours' absence it returned to its companion, and in a short time both disappeared over the wall. This is the sort of observation that one would like to see repeated with precautions, but

it is probably safe to use it as indicating at least some topographical memory. One would like to know whether the first slime-trail may have counted for something in the return journey. Land snails have a sense of smell, though its seat remains uncertain.

Very interesting experiments have been made by Miss E. L. Thompson on an American water-snail (*Physa gyrina*) which glides about in ponds, with mouth and creeping sole upwards, suspended to the surface film. The method of research was suggested by the ingenious experiments on dogs devised by Pavlov, a famous Russian physiologist. A dog's mouth waters at the sight or smell of food, and it is possible to measure the quantity and quality of the secretion. If a whistle is blown or some colour is displayed when the food is exhibited, the dog registers the association so thoroughly that in the course of time the sound or colour serves of *itself* to evoke the mouth-watering. The shadow works like the substance. Miss Thompson found that when the snail's mouth was touched by a little piece of lettuce or the like, the creature made a number—about four was common—of rapid mouth-movements. But whenever she presented the food she also pressed the snail's foot with a clean glass rod. She accustomed her pupils to the two touches at the same time, and she continued till they were "trained" to link the two together. She then gave the snail class a rest for forty-eight hours, after which she tried the touch on the foot by itself without any food. The dux of the class gave the proper munching answer the first seven trials right away, and others also did well. Some made less than the usual number of mouth-movements, and after ninety-six hours none would give any answer at all. But the general result is clear, that an animal of humble rank learned a lesson. Even the worm will turn, even the snail will learn. It learned to link together a food-touch to the mouth and a glass-touch to the foot, so that by and by it showed the mouth munchings when the foot was pressed, although no food was there. It was a lesson in association, but it did not last long.

Miss Thompson also tried whether the snails would learn

the right way and the wrong way to the surface. She fastened a Y-shaped glass tube in the aquarium, with one arm rough and leading to a slight electric shock, and with the other arm smooth and leading to the surface of the water where the snail gets fresh air. The roughness of the wrong tube was meant to be a " warning." The air was pressed out of a snail's breathing chamber and the creature was then placed at the base of the Y-shaped tube. It was, of course, of value to the snail to get its lung refilled as soon as possible. This would be attained by creeping up the smooth arm; the other arm meant failure and a mild punishment.

But the snails showed, so far as this experiment was concerned, complete incapacity to profit by experience. As the trials continued the percentage of mistakes did not diminish. It seems then that snails can learn in some cases but not in others. It is highly probable that in the course of their individual experience in natural conditions they learn to associate certain external signs with the palatability and unpalatability of various foods.

If we are to understand even a little of the long inclined plane of animal behaviour we must be clear that forming a simple association is a long way below the level of intelligence. If a bell is rung whenever food is put into the cage where tame mice are kept, they will gradually, though not very rapidly, learn to come scampering whenever the bell is rung, even though there is no food. The force of the association is too strong for them. Every one knows that the chickens will come running when they hear the familiar call that they have learned to associate with a meal. We have known a cat in a new home " learn " in a few days to come hurrying downstairs at the sound of a dinner-bell of which it had, before the flitting, no experience; but in this case the " learning " was so rapid that there is reason to suspect that there was something beyond forming an association.

In typical cases of association-forming, such as Pavlov's dog and Miss Thompson's water-snail, a stimulus that has no particular interest in itself becomes closely linked to a

significant stimulus, *e.g.* the sight or the touch of food, and likewise with the subsequent effective behaviour. They occur together so often during the process of learning that in the course of time the insignificant stimulus pulls the trigger of the effective action. This is a physiological not a psychological fact, if we can separate the two aspects; neither the dog's nor the snail's mind was at work. This is technically called a "conditioned reflex."

Superior persons sometimes speak condescendingly of the children who gather shells on the shore. Perhaps they are forgetting what Sir Isaac Newton said on this matter: "To myself it seems that I have been but as a child playing on the sea-shore; now finding some pebble rather more polished, and now some shell rather more agreeably variegated than another, while the immense ocean of truth extended itself unexplored before me." This sentence of itself, with its fine humility, is enough to dignify shell-gathering for all time.

The world is full of beauty-feasts spread out generously before us, and while it profits little to compare one with another, the shells on the shore need not yield precedence to any. A corner of an Alpine meadow in flowering time, the transfiguration of the trees in autumn, the chaffinches on the hedge, the Shetland ponies racing in the field, the cut opals in a bowl of water, and a thousand and one delightful sights—all are joys for ever; but we are not ashamed of our little shore-pool in which we have gathered a handful of shells. Even when they are high and dry, what dreams of beauty they are! These pleasing curves are the frozen music of a harmonious life—far-off hints of beautiful houses. These concentric lines are the ripple-marks of rhythmic growth, like the rings in the trunk of a tree or the zones on the scale of a fish. These nuances of colour, grading into each other, are the registrations of the ebb and flow of vital tides, just as the cross-bars on the feathers of Birds of Prey record the diurnal ups and downs of blood-pressure during the period of feather-making.

And just as one likes the irregularities of old masonry, which give it a stamp of individuality, so one enjoys com-

paring different specimens of the same kind of shell, since one often discovers personal idiosyncrasies—the answers-back that the shell-maker made to the smiles and frowns of circumstance. We venture to suggest that for the feeding of the eyes of those who can rarely see the shore, there is an



Photo · M. H Crawford.

GARDEN SNAILS IN THEIR WINTER LETHARGY.

About the month of October, when the snails are in good condition, they hide themselves in a hole in a wall or burrow into the loose soil, and close the opening of the shell with a lid of slime and lime, thereafter sinking into a state of suspended animation.

inexhaustible supply in a box of shells—rich in what one might call sensory vitamines.

The common shells of the shore are either bivalves, like cockles and mussels, oysters and clams; or univalves (Gastropods), like whelk and periwinkle, cowrie, limpet, and ormer. Occasionally one finds the unique cylindrical

Elephant's Tusk shell (Dentalium) washed up from a considerable depth; and not uncommon on the rocks are the primitive Chitons, with eight shell-pieces fitting flexibly one on another over the animal's back.

What are the characters in which the shells of all these Molluscs agree? The shell consists of carbonate of lime, and an organic substance called conchin; both are produced by the fold of skin known as the mantle, which is always adding to the shell, especially along the margin, as the animal grows bigger. The persistence of a free edge to which additions can be made as required obviates the necessity of that moulting which is characteristic of crabs and their allies. The intermittent or rhythmic growth of the molluscan shell is registered in the parallel lines already referred to, and in a few cases the age has been estimated. It is certain that a mollusc may live for a good many years, a land-snail for three or four, a freshwater mussel for a dozen. One would like to know the age of those huge Tridacnas which are often used for holding holy water in churches. The shell may weigh more than a man can lift, and may measure more than two feet across. On his *Beagle* voyage Darwin was struck by these giant clams at Keeling Atoll, and noted that "if a man were to put his hand in, he would not, as long as the animal lived, be able to withdraw it." The valves are so massive that we suppose the animal must remain quite stationary, unable to do more than allow the shell to gape a little.

Many bivalve shells show three distinct layers. There is an outer organic layer of conchin, easily rubbed off. There is a prismatic layer with the lime arranged in prisms, recalling a similar architecture in the enamel of our teeth! Innermost and often very thick is the beautiful mother-of-pearl layer with delicate flat laminæ of lime and conchin, producing for physical reasons the well-known rainbow colours. When shells in shops show this iridescent layer on the external surface, this is due to the removal of the two outer layers. If a piece of the nacreous or mother-of-pearl layer is pounded into dust, you get, of course, just white chalk; all the witchery of colour is physical or structural. There

is no pigment present in the mother-of-pearl. In the shells of most sea-snails there are three layers of platelets of lime, each layer with its own angle of slope, and the result is a porcelain-shell, often without much or any trace of mother-of-pearl. When the mouth of a Gastropod shows a deep-cut notch (for the reception of a breathing-tube), the creature, *e.g.*, a whelk, is almost always a carnivore, and apt to be unpalatable. When the mouth of the shell is uninterrupted by any notch, as in the periwinkle, the animal is a vegetarian, and likely to be palatable.

In ancient times the cult of shells was widely spread, and there are lingering traces of it to-day. Shells were used as charms and amulets, and in later days as counters and coins. Most of all, they were symbols of love and sex, of life and fertility. It is surely a rebuke to us to find how remote from commonplaceness was the old-fashioned cult of shells. Ages ago men held the empty spiral conch to their ear to listen to the whisper of the god, just as our children do to catch the reverberation of the distant sea. What is this murmur of the shell? A little may be due, some authorities say, to the shell's intensifying of internal vibrations due to pulsing blood-vessel and tensely-strung muscle, but mainly it is due to the action of the shell as a sympathetic resonator, which picks out and exaggerates certain minute sounds from the surrounding medley (for "perfect silence" is rather a fiction). But not for the world would we disturb the fancy of the child who listens to the echo of the far-off sea, and in so doing is unconsciously echoing the practice of a far-off ancestry.

XXII

SPIDERS AND THEIR RELATIVES

UNLESS one has a prejudice—not always easy to overcome—one cannot but admire spiders. Their ways are quaint and original; they are very skilful artificers; they have "sought out" many inventions, such as snares and webs; some of them make journeys through the air on threads of gossamer; others make a trap-door nest in the earth; one of them makes a web under water and fills it with dry air like a diving-bell. On a summer day we may sometimes watch a spider making a silken suspension bridge across a narrow stream, and after the bridge is finished a web is stretched across.

It is easy to convince oneself that spiders are not nearly related to insects. Thus the body is divided into two great regions instead of three (head, thorax, abdomen), the spider's head being always soldered to the thorax, whereas the insect's head is always free. There are four pairs of legs, whereas an insect has three pairs. A spider has no wings or feelers, and there is always a pair of poison-claws in front of the mouth. There are many other differences, but we have said enough to show why we must not think of spiders as insects. They are not even nearly related.

As to habits, there is good reason for thinking that the average spider is more intelligent than the average insect. It has, like the insect, a wonderful bundle of ready-made tricks or instincts, which do not require any apprenticeship, making a web, for instance; but it seems to have more freedom, more initiative, more to fall back on if it fails with its first endeavour.

The eyes of spiders, which often number half a dozen, are fixed on the top of the head, and they differ from those of a typical insect in having only one lens each, just as in our

own eyes, whereas the eyes of ordinary insects have hundreds of lenses. Spiders' eyes are simple ; insects' eyes are usually compound. Spiders are very short-sighted, and a mother seeking for the cocoon that has been stolen from her does not seem to see it even when it is quite close to her. She retrieves her treasure by smell, not by sight. Similarly, a spider does not usually see the fly that struggles on the web ; it feels the vibrations. The fact seems to be that vision does not count for a great deal in the everyday life of the spider. A beautiful web can be made in the dark, and some spiders are most active at night.

When we think of spiders we are apt to picture a rather dingy brown creature like the common House-Spider. But in warm countries there are very numerous brightly coloured kinds, many of them like living jewels. It would not be difficult to select a dozen spiders that would compare well with a dozen tropical butterflies or a dozen humming-birds. In the courtship of some brightly coloured spiders there is often what looks like a display of gay clothing. This suggests that the eyes of spiders can distinguish and appreciate colour. And it has been proved by experiment that some spiders show a distinct preference for certain colours. Thus there is one which picks out red surroundings if they are available.

There are smelling bristles on various parts of a spider's body, and they are certainly important. But the sense that counts for most is touch, which has its seat in sensitive bristles at the ends of the legs and on the second pair of mouth-parts (the pedipalps). The sensitiveness of our finger-tips does not approach the touchiness of a spider. For it can distinguish different kinds of vibrations made on the web, and act accordingly. It can distinguish the struggles of an entangled wasp, who is not welcome, from those of a fly, always welcome, and from those of another spider of the same kin, who may or may not be welcome. The spider lives in a world of touches and tremors.

It is difficult to devise experiments which will separate off sensitiveness to delicate vibrations from true hearing, that is to say sensitiveness to sound-waves. But numerous

careful trials point to the conclusion that spiders are not interested in sounds as such.

At present (1932) it cannot be said that hearing organs have been *proved* in spiders. But it is possible that they occasionally occur and have escaped detection. A good reason for being cautious is to be found in the fact that a big Bird-Catching Spider (Mygale) of India gets up on its two hind pairs of legs, shakes the others in the air, and pro-

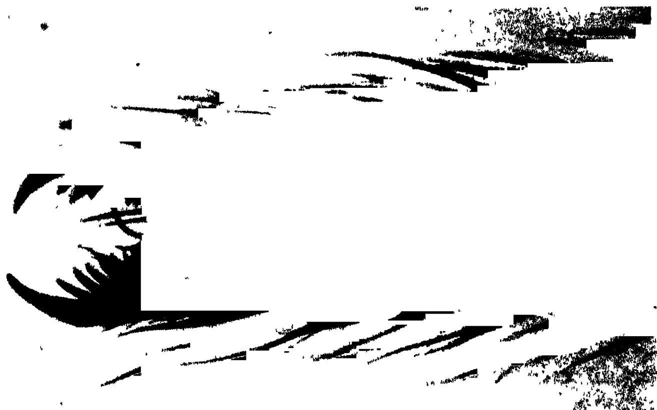


Photo: John J. Ward, F.E.S.

FOOT OF GARDEN SPIDER, SHOWING THE HAIRS AND THE COMB-LIKE CLAWS—HIGHLY MAGNIFIED.

The presence of these small teeth on the claws enables the spider to lay hold of smooth surfaces and to manipulate the silken threads.

duces a peculiar and loud noise. "It resembles that made by pouring out small shot upon a plate from a height of a few inches, or, perhaps, by drawing the back of a knife along the edge of a strong comb." It is produced by both males and females, and it is caused by rubbing a scraper on the second last joint of the pedipalp against a hard comb on the basal joint of the same appendage (the second in front of the mouth). There is also a Swedish spider that makes a sound, confined to the male. Now, if an animal voluntarily

makes a sound, it is *likely* that it can hear. But there is evidently need for further inquiry.

It seems, then, that we must be very cautious in regard to the stories about spiders coming down from the ceiling to listen to music. Much more probable is it that they are affected by vibrations quite different from sound-waves. One of the stories is that when Beethoven was a boy and used to play his violin alone in his room, a spider would let itself down from the roof and sit on the instrument. When Beethoven's mother discovered this appreciative audience she killed the spider, whereupon Ludwig broke his violin. When, in after years, the great musician was asked about the truth of this story, he said that he remembered nothing about it, but that everything, even spiders, "would have fled before his terrible scratching."

Many things done by spiders prove their great sensitiveness to tremors, and that is why we began with the senses. But many other pieces of behaviour deserve the word *dexterous*. As we lie awake in the morning, when we should be up and doing, we sometimes see a spider creeping along the ceiling above our head. This is such a familiar sight that we think nothing of it. But the spider is defying gravity! It is walking along with its legs up and its back down. It is holding on by means of a little group of very small toothed claws at the tips of its legs. In the Bible (Proverbs xxx. 28), mention is made of the spider "laying hold with its hands," but some say that the word translated "spider" refers to a lizard called the gecko, which has adhesive pads under its toes and often runs up walls. If the reference is to the spider, it quite well describes the way the curiously bent claws grip the roughnesses on such a surface as the whitewashed ceiling. The spider does lay hold with its hands.

If a flake of whitewash should break off, it is not likely that the spider will fall, for it has eight legs altogether. But even if it lost hold with all its legs, it has another resource. If it quickly touches the ceiling with the tips of its spinning-organs (spinnerets) at the hind end of its body, a jet of liquid silk oozes out and hardens instantaneously. As

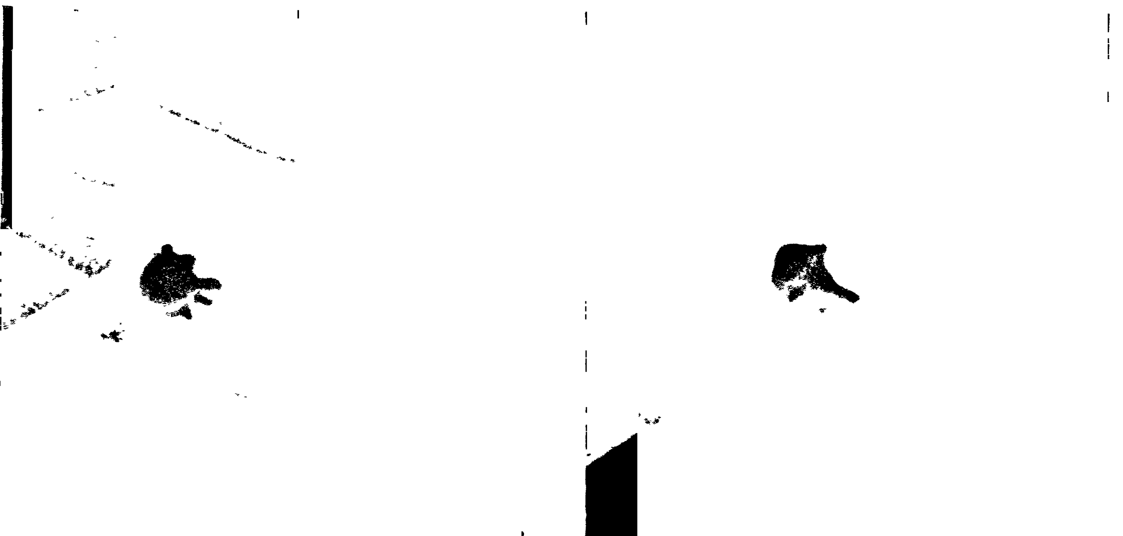
the spider sinks, it pays out more line. It is an extraordinarily neat and dignified device. But that is not all.

Apart from any breakage of whitewash or any accident whatever, a spider may come down from the ceiling on a voyage of discovery. We have often watched this—a careful descent from the roof towards our face. We have seen the spinner stop half-way in mid-air, as if to reconsider its project, and then climb up again, leaving no thread hanging. In this case, the spider coils the thread round its palps, and eventually, we believe, eats it. We have known of a man climbing up a rope hand over hand, but we never heard of him putting the rope into his pocket as he ascended. The spider's behaviour is surely worthy of being called dexterous gymnastics.

A little must be said in regard to the silk. It is made in numerous minute silk-glands inside the spider's body. Each is like an elastic syringe, and when the muscular wall contracts a jet of liquid silk is forced down a delicate duct, which opens on a bristle called the spinning-spool. These spinning-spools are borne by two to six knob-like spinnerets, each somewhat like the rose of a watering-can. But whereas the holes on the rose of the watering-can lead into a common pipe, each of the spinning spools on a spinneret communicates by a separate duct with a microscopic silk gland inside the spider's body. It is important to understand this clearly, for it explains how the spinner can make threads of different thicknesses. The strength of the thread depends on the number of silk-bags (glands) called into activity. It must also be noticed that there are often, as in the Garden Spider, two or three different kinds of silk. We say " as thin as gossamer," but a thread of gossamer is produced by *a multiple jet of liquid silk*, hardening instantaneously into the familiar delicate filament, which we hardly feel when it is wafted gently on to our face.

What are these spinnerets? The answer is rather interesting. They are transformed posterior limbs, giving us a good example of the origin of novelties from very old things turned to a new use. Spiders are evolved from Jointed-Footed (Arthropod) ancestors with numerous posterior

EGG-COCOON OF A SMALL BRITISH SPIDER (*Theridion pallens*).



Photos: John J. Ward, F.S.E.

This very tiny spider makes a cocoon larger than itself, a conical structure of white silk with peculiar projections. It fastens the cocoon by its broad end, but shifts it about with great skill so that the developing eggs are sunned. The size of the cocoon is about a quarter of that shown in the photograph. There are many of these Theridion species—about seventeen in Britain; they are very common in the summer time on bushes, where they make irregular webs. The globular abdomen is well shown in the photograph. Some of the common American line-weavers belong to this genus.

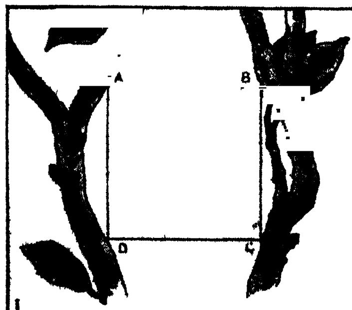
limbs, such as Centipedes show. In the embryo spider within the egg there are several posterior limb-foundations, and it is usual for three pairs to turn into spinnerets. Those that do not turn into spinnerets are short-lived structures that soon disappear. But they are tell-tale evidences of a distant past when the ancestors of spiders had numerous posterior limbs.

But what concerns us more in these Natural History studies is the fact that whenever spiders are in a difficult situation they pay out a drag-line. When a spider is walking along the top of a wooden fence, give it a gentle push, and you will be likely to see that, before it has time to fall, it has begun to pay out a drag-line, one end of which is glued to the railing. This habit of paying out a drag-line may be taken as the starting-point in making snares among the grass, which point the way to true webs ; in weaving a cocoon around the eggs ; and in spinning the long gossamer-threads that are used in ballooning through the air.

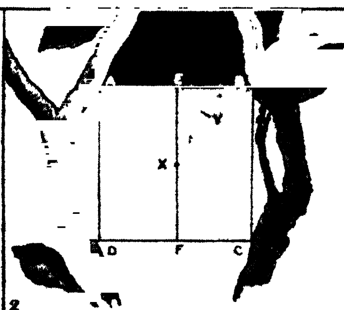
A drag-line tangled among the leaves of grass might be useful in capturing insects, and a snare is little more than a mesh of threads without particular arrangement. But some of the threads are sticky with drops of insect-lime. From a snare it is easy to pass to a cobweb such as we often see in the top corner of a stable. It differs from a true web in being little more than an irregular sheet of threads. The third grade is well represented by the beautiful orb-web of the Garden Spider (*Epeira diademata*). Let us think over its making, shown in the accompanying diagrams.

The first stage is *laying the foundation lines*, which enclose the chosen area. They are made specially strong, for they may be used over again if the web breaks down. The spider pays out a drag-line from A—B, and pulls it taut ; and so from B—C, C—D, and D—A, supposing there are four sides.

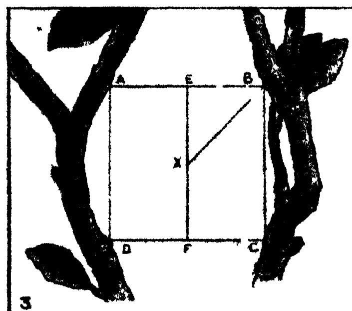
The second stage is *making the rays*. From the middle point (E) of A—B, the spider drops down to the middle point (F) of C—D, and pulls the drag-line taut, as a sailor would say. That line E—F is the first ray. Then the spider climbs up FE, but pauses at the middle point X, the future centre of



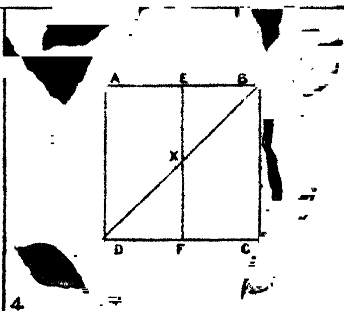
Four foundation lines



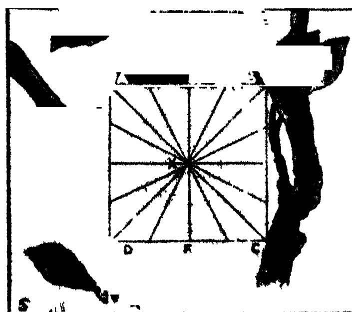
First vertical line, E—F. X the centre. Y, the making of a ray, X—B



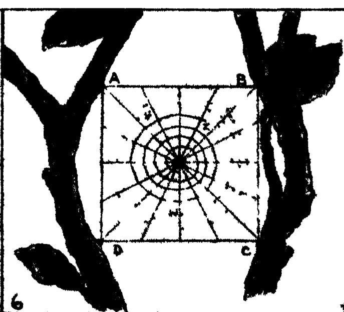
X—B, drawn taut



Another ray X—D



More rays are made, first to one side and then to the other, so that there is no unequal strain. And now the spider commences the final stages of the structure



Dark spiral the primary spiral—a scaffolding partly removed, stopping at Z. Dotted spiral the viscid secondary spiral just begun, stopping at W

the web. It must have some sense of proportion. From the centre it climbs up to E, paying out a line, but keeping it from entangling with FE. It walks along to B, continuing to pay out, and then pulls the line taut, thus making the third ray, XB. Back to the centre it goes, and begins again to spin a thread. It walks down to F and along to D, and pulls the fourth ray straight. We need not continue further. Many rays are made, and in such an order from side to side that the centre is not pulled out of position.

The third stage is *making the primary spiral.* Starting from the centre and taking rather big steps from ray to ray, the spider lays down a spiral, which is glued to each ray as it crosses. But this first spiral is not sticky.

The fourth and last stage is *making the second spiral.* This is laid down from the circumference inwards, and is the final web, the first spiral being used as a scaffolding only. In making the second spiral the spider takes shorter steps, and the thread that is clamped on ray after ray is sticky. It is covered with minute droplets of what looks like dew. As the web is completed, the spinner removes the first spiral, eating it up in point of fact.

From the hub of the web there is usually a special thread going to the nest, which may be round the corner, and by the vibrations of this thread the spider is made aware of the character of the visitor. We have often brought a spider out from the nest by twirling between our finger and thumb a thread of sewing silk with a tiny fragment of cork at the lower end, and allowing this to touch the web from time to time. Sometimes a spider seems to hold the web-nest line rather tightly, and then let it suddenly go, which may make the fly's entanglement doubly sure.

There are many different kinds of webs, some upright, and others horizontal, some like tents and others like domes ; and sometimes it is necessary to distinguish between the web itself and the external scaffolding which keeps it trim and taut. But what are we to think of the achievement ? Is it the outcome of an inborn gift, or of intelligent skill ? There can be no doubt that in the main the making of the web is instinctive. For the very first time a grown-up spider makes

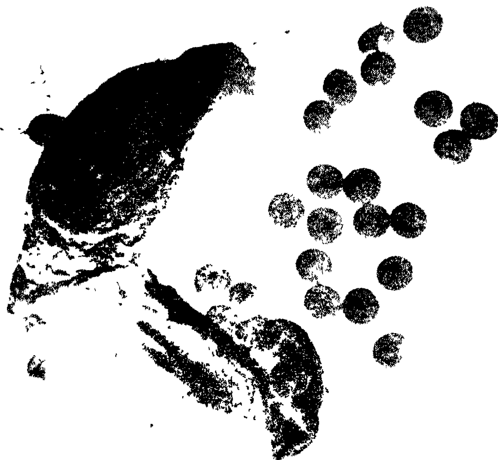


Photo : M. H. Crawford.

EGG-COCOON AND EGGS OF HOUSE-SPIDER.

From 60 to 100 eggs are laid at a time, and the cocoon is fixed in a safe corner. It is here shown highly magnified.

a web, it makes one after the fashion of its kind. Its architecture is true to pattern, but the weaver does not deliberately follow any pattern. It weaves as to the manner born. The female spiders make the finer webs, but they are all equal. The males are usually smaller, sometimes much smaller, but their standard, so to speak, is not so high. It must be noted that a fine web can be made in a dark box in the course of a few hours, and by a spider who never made one before. This is the mystery and miracle of instinct !



Photo: Hugh Main.

EGG-COCOON OF BANDED SPIDER (*Epeira fasciata*).

The globular silken bag is suspended from grass or twigs and is well concealed amongst the herbage.

But is there no intelligence at work in the making of the web? The answer must be, we think, that glimmers of intelligence are to be discovered when there is something peculiar in what is done—some departure from the usual routine. Thus a web in a gusty place, between two rocks on the seashore, may show very interesting special lines which keep it from being blown out of place. Sometimes minute pebbles are fastened by silken ropes to the lower margin of a vertical web, so that it is kept more or less taut, just as we



Photo: E. J. Bedford.

WOLF-SPIDER WITH EGG-COCOON ATTACHED TO HER ABDOMEN.

The Lycosids or " wolf-spiders " are wandering hunting spiders, making no snare or web, sometimes burrowing, sometimes without any home. The mother carries the egg-bag or cocoon with her as she journeys, and vigorously defends it against all her enemies.

sometimes have a heavy roller fastened to the foot of a lantern-screen.

We sometimes find a flat web with foundation lines stretching right across a stream, from the bushes on one side to those on the other; and the question rises how such a problem has been solved. Standing on a high twig, the



Photo: E. J. Bedford.

EGG-COCOON OF FAIRY-LAMP-MAKING SPIDER
(*Agrœca brunnea*).

The elegant cocoon of this British spider is hung from grass or heather, or the like, by a short stalk. It is a quarter of an inch in diameter, and contains about fifty yellowish eggs attached to the roof, but in a short time the mother spider plasters it over with moist earth and closes the opening below.

spider pays out a long line of silk, the free end of which is gradually pulled by the wind till it entangles on a bush on the other side of the water. Then the spinner feels that there is no longer any tug on her spinnerets, and she stops spinning. Ever so gently—here, perhaps, there is some intelligent judgment—she pulls the line straight and fastens the near

end firmly to the twig. Then she ventures across the frail swinging line, paying out a second line which joins on to the first. If she gets across safely, the line is twice as strong as it was, and the journey may be made several times. When one line is secure, there is no great difficulty in making a second parallel to it, a short distance off, and then others going crosswise, till there are firm foundation-lines for the web proper.

There is a pretty story, told by Dr. Goeldi, of a Brazilian spider, common in gardens, whose web for a long time escaped discovery.

A boy-naturalist, Dr. Goeldi's son, undertook to watch the spider through the twenty-four hours in the hope of solving the puzzle. He discovered that the spider made its web in the small hours of the morning, and that it caught small insects (male scale-flies) that flit about very early or very late. When the sun rose the spider unfastened its web, full of booty, folded it carefully up, put it on its shoulder, and carried it to the nest, where the contents were dealt with at leisure.

EXTRAORDINARY SPIDERS

So much admiration is lavished on ants, bees, and wasps that there is apt to be a scarcity when we come to spiders. Yet they often exhibit an originality and daring that cannot be surpassed among insects. When naturalists come to know spiders better, it will be found that, though well provided with a repertory of instincts, they have a more active intelligence than insects usually display. We are using the word intelligence to mean an ability to put two and two together and to profit by experience by perceiving in some measure the relations of things.

As our first illustration we take the large Australian spider called the Magnificent (*Dicrostichus magnificus*), whose habits have been well described by Mr. Heber A. Longman. The adult female, with whom we are concerned, is about half an inch long and equally broad. But what colouring! "The abdomen is cream-coloured above, with darker

vermiculations and a mosaic of fourteen salmon-pink spots on the front edge; the two prominent tubercles are yellowish. The dainty little turret on the cephalothorax has an alabaster base, and the wine-coloured turret itself supports two pairs of eyes." It is not for nought that this spider is called the Magnificent.

She makes remarkable cocoons, three to four inches long, with a maximum diameter of about an inch. They are hung from twigs, and look like pendant white fruits. The spider may spin about five of these silken bags in a season, and each contains about six hundred eggs. But they are not simple bags. There is an inner cocoon, beautifully pear-shaped, with a texture like fine rice-paper; the outer envelope is much larger and stronger; and between the two there is a loose packing of delicate silk. The whole structure is finished in one night, sometimes in moon-light, but equally well in the dark. It is a typical instance of instinctive behaviour, involving a multitude of movements, but without deviation from routine, even when that would be useful. During the day the spider rests in a retreat among the leaves. When the spiderlings are hatched they work their way out of the cocoons without any assistance; they climb to the top or on to adjacent leaves; they spin fine ballooning threads which are caught by the breeze and away they go. Mr. Longman thinks that the majority of the little aeronauts are captured by sparrows before they get far from their cradle.

But more extraordinary than the cocoon-making is the method used in capturing moths. During the cocoon-making season at least there is no sticky web or other snare entanglement, but there is an extraordinary device. The spider makes a filament, usually about one and a half inches in length, which is suspended downwards, and bears at its end a globule of very viscid matter a little larger than the head of an ordinary pin, occasionally with several smaller globules above. Now we must let Mr. Longman tell his story. "The filament was held out by one of the front legs, the miniature apparatus bearing a quaint resemblance to a fisherman's rod and line. On the approach of a moth

the spider whirls the filament and globule with surprising speed, and this is undoubtedly the way in which it secures its prey. The spectacle of the moth fluttering up to the spider, sometimes two or even three times before it was caught, is one of the most interesting little processes which the writer has ever witnessed in natural history. The supposed desire of the moth for the star is a poet's fancy, but the attraction of the moth to the Magnificent Spider, although mysterious, can be seen by any patient watcher." The globule is so gluey that leaves can be hung on it by a mere touch; and the moth, once in contact, is as helpless as a fly in ointment. The captured moth is drawn up to the Magnificent, apparently killed by an injection, neatly bound in a little bundle (probably to keep the legs and wings out of the way), placed in front of the spider's mouth, and then sucked dry. For spiders always feed on juices, not on solids.

How are we to estimate such behaviour? That angler casting for aerial fish, and with a bait that is also a hook! Is the Magnificent's device, nowadays an inborn aptitude, the outcome of ages of Nature's picking and choosing among new departures in methods of snaring? Is it comparable to her cocoon making? Or can it be genuinely intelligent both in origin and in persistence? This would not be inconsistent with the spider's serving an apprenticeship in angling, which might include taking imitative advantage of the dexterities of other spiders. We should gladly hear more of these matters, for the truth is we have not facts enough. What we personally feel quite sure about is that the Magnificent Spider-Angler, whirling her deadly line, is not a mindless automatic machine.

Let us now shift the scene to South Africa (Pietermaritzburg), where a relative of the Magnificent Spider has been recently found and studied by Dr. Conrad Akerman. It is called Clavomela, and the adult female is about three-fifths of an inch long and of striking appearance. Large cocoons, up to five in number, are set in a row on grass stems bound together. They look very like fruits. Within a very tough silken envelope there is loose floss-silk surrounding the

eggs. During the day the spider sits huddled beside her works of art, to which she herself has a strong resemblance; but she becomes alert at dusk and begins angling for insects. She spins a thread with, at its end, a pinhead-like viscid globule, holds it out on her third or shortest leg, and whirls it rapidly with a rotary motion in a horizontal plane. She keeps this up for about fifteen minutes without a pause, then draws up the thread and swallows the viscid droplet. After resting for a few minutes she repeats the performance, spinning another line with a terminal globule and rotating it again for about fifteen minutes. The renewal of the globules, which suggests changing the bait, is probably connected with the fact that the globule gradually loses its stickiness on continued exposure to air. The droplet is always rotated in a clear place and is thus kept off stationary objects; but the capture of the booty has not been observed as yet.

It will be seen that the idea in the behaviour of the Natal spider is the same as in the case of the Brisbane spider, though the details are different; and the question rises whether the remarkable habit has been independently evolved in the two countries, or whether the two spiders are descended from common ancestors which exhibited the device in somewhat simpler expressions.

From inside big bunches of bananas imported to this country we have twice or thrice procured living spiders of formidable size, representatives of the predatory types which sometimes kill and suck small birds. But there are even stranger feeding habits. Thus an Argentine zoologist has described a spider that drove a tadpole into a funnel-shaped net which dipped into shallow water; and there is a South African species that has been known to kill and devour not only tadpoles but small toads and tree-frogs.

From time to time there have been reports of spiders that captured small fishes, but they have been lacking in detail. Now we have a careful description by the Rev. Nendick Abraham, who watched both the fishing and the meal in the case of a Natal spider, a species of Thalassius. The name suggests the sea, but the fishing is in fresh water. The

spider spread itself out on the surface of the aquarium, but kept hold of a projecting stone by means of its hindmost legs. When a small fish came swimming underneath the spider made a rapid plunge and caught its booty without letting go of the stone. The spider drew the fish ashore and began without delay to eat it, or perhaps one should say to drink it. For there is probably a rapid digestive solution outside of the mouth. In any case, the fish disappeared. There is another spider that . . . but perhaps we have said more than enough already.

SCORPIONS

Characteristic of deserts and warm countries, or well-sunned waste places, as in the South of France, is the tribe of scorpions. They are very unlike most other animals. If one's acquaintance with mammals were limited to such typical representatives as dog, horse, and rabbit, one might have some difficulty in recognising that bats and porpoises are also mammals. If one had been brought up among ostriches and knew them as birds par excellence, one might be a little puzzled in applying the same name to a storm petrel or a humming bird. But whoever has once looked for a vivid moment at any kind of scorpion would recognise instantaneously every other kind. There are many different genera, but scorpions could not be confused for a moment with spiders or with lobsters or with insects. The differences between one kind of scorpion and another are within a narrow radius.

What are the distinctive features? The head and the thorax have coalesced, and are covered dorsally by a hard "cephalothorax" shield, which bears several pairs of simple short-sighted eyes. The posterior body or abdomen consists of seven broad rings and five narrow ones, behind which there is a sharp-pointed sting. Like other spiderish animals or Arachnids, the scorpion has no feelers, though it is one of the most sensitive of creatures to everything that can be touched. In front of the mouth is a small pair of pincers (cheliceræ) for holding the food close or for tearing it to

pieces. Second, there is a pair of large clawed appendages (pedipalps) for seizing the food, for fighting with, and for "joining hands" when two mates indulge in their remarkable "promenade á deux," as Fabre called it. Then come four pairs of walking legs; and on the front of the under-surface of the abdomen there is a pair of curious combs (pectines) that are very tactile, and feel what the scorpion crawls over. Behind these combs can be seen four pairs of oblique slits leading into the purse-like lung-books which are suited for breathing dry air.

The whole body is strongly armoured with a non-living cuticle or armour of chitin, and on strategic places there are numerous touch-bristles.

Scorpions are children of the desert and able to do without water. That is to say, they obtain the necessary fluid from the insects and spiders on which they feed. They move quickly, with the tail usually upraised, rarely trailing; they catch their booty with their pedipalps, and if there is a struggle the sting injects poison. They seem to care more for the juices than for the solid parts of their victims. Like many spiders, they can survive for months without eating anything. In natural surroundings, however, they prefer cannibalism to fasting, and Fabre notes grimly that if two scorpions are found under the same stone the one is always engaged in eating the other. Sir Ray Lankester cites an experience recorded by the old naturalist Maupertuis. He had 200 scorpions in a cage in the South of France, and had to leave them to themselves while he obeyed a summons to Paris. On his return he found one plump scorpion in the box, surrounded by the disjecta membra of the others. "The survivor was in the position of Gilbert's ancient mariner, who said that he was 'the cook and the mate, and the captain's boy, and the crew of the Nancy brig.'"

Scorpions hunt in the twilight and darkness, trusting to their tactility. They lie in hiding during the day under stones or in holes. But, like many animals that avoid the light of day, they are "attracted" at night to the abnormal glare of a camp fire. This is one of the "moth and the candle" phenomena.

The venom of the scorpion is manufactured in a double gland inside the tip (or telson) of the tail, and it is injected into the victim through two minute holes at the sharp down-curved point, which is thrust upwards and forwards in the actual stroke. The poison has a very rapid paralysing action, and it may produce serious symptoms in man, though the name Androctonus ("man-killer") of one of the worst kinds is not to be taken too literally. The old story about scorpions committing suicide when surrounded by a ring of fire is not good Natural History. In the first place, it is not certain that they could thus wound themselves, unless they managed to insert the sharp tip of the sting between two joints in their armour. In the second place, even if they could wound themselves, the poison would not be injurious; for they have in their blood, owing to the normal absorption of small quantities of the poison from the glands, an anti-body or counteractive which neutralises the effect of an experimental injection, and would do the same in the case of an attempt at suicide. In the third place, they do *not* sting themselves; the suicide does not happen! Even when they fight savagely with one another they use the pedipalps and do not sting. It should be recalled, however, that experiments made with due precautions showed that scorpions surrounded by a ring of fire rush about for a little and then "faint." That is to say, they pass, as many endangered animals do, into a fit-like or cataleptic state of rigidity, from which they recover if the crisis is safely passed.

The two sexes of scorpions are almost quite the same, except that the male has larger combs. Fabre has given a picturesque account of the mating. The two scorpions stand face to face and raise their tails upright over their bodies till the two stings touch. The male clasps the female's pedipalps with his, and bids her come along. He walks backwards; she has to follow. Often the way is long and the promenade lasts for an hour or more. At length, without letting go his hold, the male burrows backwards under a flat stone and the two of them disappear into the retreat. The male's usage seems to be somewhat rough, and he often pays for it with his life. For after the consummation, as Fabre

observed, the female often devours her mate. Her tender mercies are cruel.

Scorpions pass through their slow development within the mother, and they are fully formed when they are born. Thus scorpions are usually described as viviparous. It should be noted, however, that Fabre's account of the matter is that what pass from the mother are fully formed miniature scorpions that are still wrapped up in their egg-envelopes. With fastidious care the mother scorpion tears off the egg-membrane and thus liberates the delicate miniature. In the Languedoc scorpions the new-born offspring are about three-eighths of an inch long, the adults having a length of over three inches, but the new-born little creatures are quite perfect in structure. They climb up the appendages and settle down on their mother's back, apparently gripping the bristles with their claws. There may be two dozen of them entangled on the mother ; she is " clad in her children " and greatly resents any interference. For the first week they do not feed at all, yet they grow larger, doubtless through internal utilisation of reserve food and through rearrangements of molecules. This growth necessitates a first moulting, during which the cuticle comes off in shreds. The young ones are now able to move about on the mother, and it is reported that they share her meals. They go on growing and moulting, but the later moults differ from the first one in being very neat. A single crack or fissure occurs in the region of the cephalothorax, and it is through this that the body is carefully extricated, leaving a ghost-like husk behind. A mother scorpion may carry two dozen young ones on its back—one of the many quaint experiments in parental care ; and a rather pretty point is that after the young ones have ceased to be carried about they sometimes betake themselves to the old retreat when danger threatens.

It must be noted, however, that scorpions are animals of some individuality, each species " itself and no other," so that the accuracy of Fabre's account of the Languedoc scorpions is not impugned if the life-history of other species turns out to be different in detail. Here is one of the many opportunities for fresh observations.

AS REGARDS MITES

There is something to be said for comparing mites (Acarina) to cave-animals, first, because there are a great many species of mites in caves; and, second, because there are many kinds of mites that live in deep crevices and dark corners that correspond to caves on a small scale. Even the inside of a cheese may be thought of as a cavern. On the other hand, it is well known that many mites are active swimmers, while others move about among the herbage. Others again have given themselves up to parasitism.

Many races of animals have had, or still have, their giants. There are whales and mammoths among mammals; ostriches among running birds; albatross and condor among flying birds; pythons, crocodiles, giant tortoises, and turtles among reptiles; extinct amphibians as big as donkeys; great fishes like sharks and congers, and tunnies ten feet long. We need not continue the list, but the general impression we get is that it is not well for an animal to be too big. The gigantic is not a successful line of evolution. Where are the giant terrestrial reptiles, the Labyrinthodont amphibians of the Trias—one of them with a skull a yard long; the Ammonites as big as cartwheels? Each age has had its giants, but the giants do not last.

Much more successful is another trend of evolution —towards dwarfs; and one reason for success is plain, that minute size makes escape easy. Think of the harvest-mouse swinging on the wheatstalk, the humming-bird with a nest the size of a thimble, a tree-frog just over an inch in length, and fishes smaller than minnows. But these are relatively gigantic compared with the minute crustaceans known as water-fleas or with some of the spiders. Smaller still are some of the insects, which may be under a millimetre (one twenty-fifth of an inch) in size. It is often said that the smallest known insect is one of the Hymenoptera, *Alaptus excisus*, which is about half a millimetre in length. But it has relatives not exceeding one-third of a millimetre, and there are some beetles which are only one-fourth of a millimetre long! This brings us to think of

an animal about one-hundredth of an inch in length, and yet containing a full equipment of organs—such as brain, food-canal, and breathing tubes. It rather taxes the imagination!

We feel the same in regard to mites, many of which are quite microscopic, even less than a hundredth of an inch. As it is said in *The Cambridge Natural History*, "taken all round, a millimetre may be considered a large size for a mite." Little wonder that their name is legion, that they have a world-wide distribution in crevices or as parasites, and that they are very difficult to eradicate when they once get a foothold. It is probable that the minuteness has its chief value in enabling mites to get at food-materials even when well protected, and to disappear through holes like the eye of a needle, and to feed upon microscopic droplets of juice, sometimes eked out with not less miscroscopic organic crumbs. But many of them are able to survive for a long time in very unpropitious conditions, and perhaps there are physical reasons why their minuteness helps them to withstand extremes of heat and cold and drought.

Mites or Acarines are not related to insects, but they have affinities with spiders and scorpions. The body is apparently all one piece, except that the foremost part sometimes forms a movable false head—called the capitulum. The posterior part of the body (the abdomen) is unsegmented, except in one case (Opilioacarus). The anterior part of the body consists of head and thorax run together, and in most cases this cephalothorax is marked off from the abdomen by a distinct groove. There are two pairs of mouth-parts suited for sucking, but often also for biting or piercing. There are no feelers, but there are often eyes. There are four pairs of legs, which are often more or less degenerate in the parasitic forms. The more active mites, like harvest-mites, breathe by air-tubes; the more sluggish ones, like cheese-mites, breathe through their skin—the most primitive way of breathing.

What comes out of a mite's egg is almost always a *larva* with three pairs of legs. The acquisition of another pair marks the beginning of the *nymph*-stage, during which there

is great activity, followed by quiescence. The outcome is the fully formed adult. The nymph may be very unlike or very like the adult, but there seems to be a considerable internal change marking the growing-up or adolescence. In the " Cheese-mite " family some of the nymphs become strangely transformed, with a hard protective covering on their back, and with adhesive suckers below the hind part of the body. These strange forms—called " hypopial "—fasten themselves by their suckers to insects such as humble-bees, and the meaning of the remarkable change of structure and habit is to secure dispersal. The travelling forms are very hardy and can survive for a long time without food. When their insect-chariot stops at a suitable place the mites let go ; and if they are lucky they continue their development, changing back into the ordinary nymph form. This is one of the ways in which mites spread.

There is an interesting variety of habit within the class of mites. The freshwater mites, which are often vividly, sometimes protectively, coloured, illustrate what is meant by *indefatigable* ; they are never tired ; some of them seem *never* to stop swimming about in pursuit of their prey. Much less attractive is the small group of marine mites that crawl about on seaweeds and zoophytes in the shore area. The " harvest-mites," often velvety red, hunt among the grass for various kinds of small animals, such as insects. When the larval forms of the British " harvest-mite " (*Microtrombidium holosericeum !*) get on to man they fix themselves at the base of a hair and give a bite, the consequences of which are very irritating, especially to thin-skinned people. A little ammonia removes or lessens the pain, and oil of citronelle applied to such parts as wrists and ankle is a useful preventive. It is not clearly understood why the bite should cause so much irritation, but it is noteworthy that a Japanese species carries a microbe of some sort which induces a serious " river fever," called Kedani disease.

The hard-shelled " beetle-mites," or Oribatids, feed on decaying vegetable matter ; the leathery or hard ticks spend part of their life sucking backboned animals, and are instrumental in spreading several serious diseases, such as

"tick fever" in man, and "heart-water" in cattle. The "snouted mites," usually red in colour, are free-living and predatory, but their larval forms often hang on to the legs of insects and spiders. Belonging to a different family are the species of Gamasus that we often see clinging to the black dung-beetle if we turn it upside down on the roadside. The so-called "red spiders" (Tetranychus) are sap-sucking mites that do much damage to fruit trees and bushes and greenhouse plants. The popular name refers to their habit of spinning underneath the leaves a silken web, within shelter of which they lay their eggs and continue their sap-sucking. On a very different tack are the "cheese-mites," most of which live upon decaying organic matter, and every one is familiar with the crowds of miners in the great caverns of the cheese. The itch-mites and mange-mites tunnel in the skin of mammals, clear evidence, apart from cases of fortuitous infection, that there has been insufficient attention to cleanliness. On the same lines are those that give poultry their "scaly leg," or cause them to pull out their feathers, and those that give sheep their "scab."

Quite by themselves are the Tarsonemidæ, minute vegetable-eating mites, one of which, now called *Acarapis apis* was shown by the Aberdeen investigators (Rennie, White, and Harvey) to be the cause of the widespread and disastrous Isle of Wight disease of bees. It is remarkable in having as its haunt certain breathing tubes of the bee, thus illustrating the characteristic mite tendency to explore minute crevices. But the life-history of this serious internal parasite is still imperfectly known. Another famous mite is that which has ruined so many black-currant bushes all over the country. It is a very minute, worm-like mite that feeds between the leaves of the buds, and so irritates them that they swell up and fail to open as they should. The result is well described as "big bud." Not distantly related are the minute, worm-like "follicle mites" (Demodex), which occur in various mammals in the moats from which hairs spring. The visible anterior ends are familiarly known in man as "blackheads." They must be the commonest of human parasites.

We see then from these samples that the quest for food among mites is very varied. The diverse methods form a sort of epitome of what occurs throughout the animal kingdom as a whole. Carnivorous, vegetarian, saprophytic, parasitic; borne about by animals, crawling over plants, burrowing in the ground, in freshwater, and in the sea; what variety there is! The linkages with other creatures are often subtle; one mite makes a vehicle of the bee and another invades its interior; one mite eats the honey in the hive and another mite devours the honey-eater; and the most subtle linkage of all is that many mites are the carriers of microbes which bring even man to the dust.

XXIII

INSECTS AND THEIR WAYS

As regards variety and numbers and distribution, the class of insects is the most successful in the whole Animal Kingdom. There are far more species or kinds of insects than of all the other animals taken together. Many zoologists would say that a quarter of a million is a low estimate for the different kinds of insects that are more or less known ; and there are, no doubt, many still to be discovered.

A typical insect has a body divided into three regions—head, thorax, and abdomen. The head bears feelers, compound eyes, and three pairs of mouth-parts which differ greatly according to the nature of the food. The thorax bears three pairs of walking-legs and two pairs of wings. In the adult the posterior body or abdomen does not usually bear more than hints of appendages, but these are often to be seen in the larval stages. The whole body is covered with a non-living husk or cuticle of chitin, which is moulted repeatedly during the rapidly growing young stages. Except in Mayflies there is no moulting after the wings have developed. All insects breathe by air-tubes or tracheæ which carry the air to every hole and corner of the body. In the higher insects—like Bees, Butterflies, Beetles, and Two-winged Flies—there is a complex life-history, including larval and pupal periods.

In the Class there are many Orders, *e.g.*, Hymenoptera (Ants, Bees, and Wasps) ; Lepidoptera (Butterflies and Moths); Coleoptera (Beetles); Diptera (Two-winged Flies).

SOCIAL LIFE OF INSECTS

Life in a bee-hive goes on all the year round, though very nearly lulled to sleep in the winter months. Summer is

the busy time. On a warm summer day, when the air is sweet with the scent of flowers, the work of the honey-bees is in full swing. From the hive comes a murmur that tells of activity within, while the threshold is thronged with workers.

There is a constant coming and going. Bee after bee sets off to the gardens and the fields, to forage—not for herself, but for the community to which she belongs. These outdoor workers are the strongest bees ; the younger and weaker ones are " house-bees." Back come the foragers from the fields, and some of the house-bees are ready to meet them, and relieve them of their loads. Many different loads are brought to the hive. Some bees bring full sacks of honey to add to the store ; others carry pollen, of every shade from palest gold to russet-brown, neatly packed in the two " baskets " on their hind legs ; while others still have been to the pools in search of water.

The house-bees take charge of the spoils, and pack them away in the storehouse of the combs. If a bee comes in, with pollen covering all her hairy body, house-bees are ready to comb her down and collect the precious dust. Collecting and storing, this is an important part of the work, but there are other necessary labours that can be noticed at the gateway of the busy city. Loads are brought out of the hive too, all manner of waste material, and the bodies of dead bees, for everything must be kept clean and orderly inside. Intruders such as slugs, too big to carry out, are covered over with wax. The air must be kept fresh, too, so bands of workers act as fanners. Rows of bees stand motionless except for their ceaselessly beating wings. They are drawing the stale air out of the hive, and letting a current of pure air rush in. The fanning also helps to evaporate water from the honey, making it " riper." As the fanners get tired, their places are taken by other workers.

Near the hive, bees may be seen flying about in the sunshine, and taking no part in the carrying to and fro. These are drones or male bees, which do not share in the work of the hive, and, indeed, even beg for honey from the busy workers. But it cannot be said that they are sluggards. Inside the

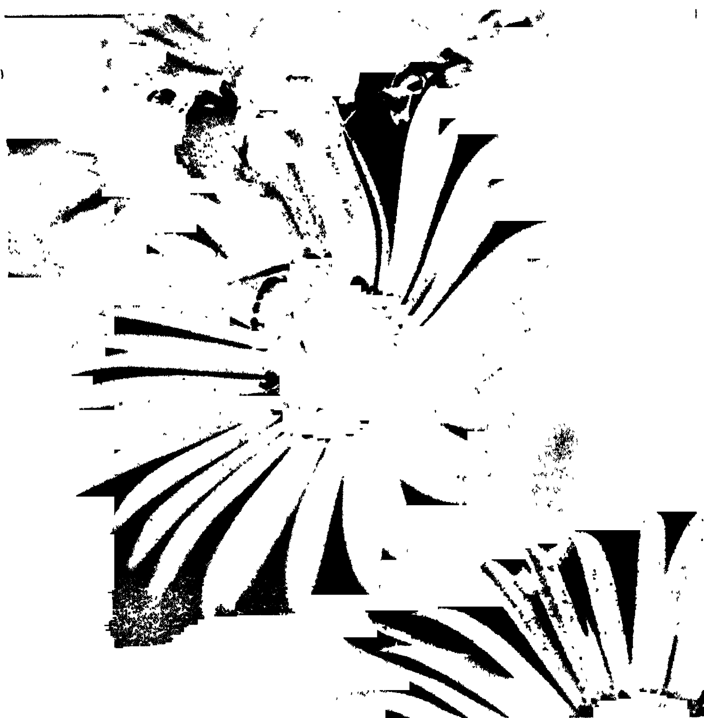


Photo: G. H. Hewison.

HONEY-BEE GATHERING POLLEN FROM LEOPARD'S BANE (*Doronicum*).

From some flowers the bees collect the nectar, which they change into honey, and from others they collect pollen, which is chiefly used as food for the grubs. But there are some profitable blossoms that supply the bees with both.

hive is the third kind of bee, the queen, the mother of the workers and the drones. A peep inside would show the queen passing over the combs and laying an egg in every empty cell. This is the whole of her work, but she does it almost continuously for many weeks at a time, and new generations of her offspring are continually emerging.

The indoor work is divided among other workers. Some guide the queen in her progress and give her food ; some

are busy in the nurseries, feeding the young bees ; others are making wax, or building new combs. There are cleaners and repairers ; honey-brewers and store-keepers ; and there are guard-bees that keep watch day and night in this well-ordered city.

One can hardly call " swarming " a natural phenomenon, for the hive-bee is a semi-domesticated animal—the subject of man's breeding experiments and subservient to his control in many ways. But it is a very striking phenomenon in the life of the country during the early summer, and its human interest is not lessened when it is accompanied by the more or less superstitious custom of ringing bells and beating kettles. The old-fashioned method was to rattle the door-key against a frying pan, and its object was to induce the swarm to settle in a convenient place from which it could be collected by the owner, who has the right to follow his errant property even into his neighbour's garden. But it is far from certain that " tanging " has any efficacy at all ; there are some entomologists, indeed, who would deny that the excited bees have any sense of hearing.

What does a swarm mean ? In a general way " swarming " may be described as a migration from a well-peopled hive ; but it would be too simple to say that it is merely the outcome of overcrowding. It is commonest in early summer, and usually takes place on a fine forenoon. The queen, instead of laying eggs as usual, moves restlessly about over the comb, and she infects the workers with her own uneasiness. They become feverishly excited and rush out of the doorway as if in a panic. The queen follows her children, and they will not settle unless she is with them. If they lose her—for, being weighted with eggs, she is apt to fall to the ground—the swarming bees will not settle. They may return to the hive in a short time, and they may repeat the experiment soon afterwards with a young queen as leader.

The normal outcome of the swarming is a new community, and if the bee-keeper does not recapture the excited throng, the result may be that a settlement is made in a hollow tree or in some other place which is suitable for bees, though

not for their owner. In some parts of the country there are many communities of honey-bees that have become wild or "feral." Swarming bees sometimes find very suitable places, but it is highly improbable that they send out scouts to discover good lodgings. Enthusiasts have a tendency to forget the extreme unsuitability of many of the places in which the swarmers sometimes settle down—being compelled to settle by the simple fact that the queen cannot fly any farther.

The swarming bees pour forth like a torrent, and whirl in the air like a dust cyclone. They are not usually out of temper, for they take a good meal before they start, but they are beyond doubt greatly excited. They may be thousands strong, and they make a characteristic noise which sounds gladsome to generous ears. Part of the buzzing is simply due to the very rapid vibration of the wings; but there is another sound that is produced by the rapid passage of out-breathed air from the narrowed openings of the air-tubes.

The sense of smell is raised to the *n*th power in hive-bees, and it is probably by the absence of a certain fragrance that they become aware that they have lost their queen. If she is with them, all is well; and they cluster in a dense mass, like a scrimmage in football, but multiplied a hundred times. They hang together on a branch in a close packed crowd, forming a mass sometimes as big as one's head, and the bee-keeper who knows his business has rarely much difficulty in transferring them to a cool, clean hive. That indeed is just what they want. What puzzles the naturalist is the *concerted action* amid the excitement, for we cannot any longer think of them in the old way, which read the man into the bee:

> "Swift as the falcon's sweep, the monarch bends
> Her flight abrupt: the following host descends
> Round the fine twigs, like clustered grapes they close
> In thickening wreaths, and court a short repose."

What we have spoken of is a normal primary swarm which relieves the pressure of pqpulation in the old hive and leads to the starting of a new community. But a swarm may be prompted by other conditons besides overcrowding and lack

of empty combs for egg-laying and honey-storing. It may be lack of sufficient ventilation in the hive, or an over-production of drones, or some other cause of discomfort that brings on the "swarming fever."

We must also distinguish the primary swarm led by the old queen, the mother of all her retinue of workers and drones, from a secondary swarm led by a young queen who has been developed (in about a week) in one of the royal cells of the old hive left queenless by the swarm. This young virgin queen becomes aware of her unhatched sisters within the royal cells, and utters a "piping" sound, interpreted by some as indicative of angry jealousy. If she is allowed, she will tear open the cradles and sting her younger sisters as long as her strength lasts. But the workers do not usually allow such extreme measures. The young virgin queen may lead off a secondary swarm a day or two after the piping, or she may not leave the hive till she flies forth on her nuptial flight, whence she returns fertilised and maternal, never to come out again unless she leads off a primary swarm. We must not leave this familiar story, which never loses its strangeness, without noticing that it is the bee-keeper's business to *prevent* "natural" swarming, which is apt to be wasteful, by methods of control that are always becoming more subtle as the fine art of bee-keeping calls science to its aid.

The bee-community is at the height of its prosperity in summer: active, industrious, harmonious. The other seasons have their varied pictures to show. Autumn is a time of distress. The air grows chilly, and flowers grow scarce, and tired bees leave the hive and make no return journey. The ranks are thinned. Then it is that robber-bees try to plunder the honey-stores. Then, too, is the time of the tragedy of the drones, for one day the workers turn on them, who will feed though they do not work, and kill them all. In many cases, however, there is no *massacre*, but rather a prolonged cold-shouldering which is just as fatal.

Winter comes, and work ceases. The bees that remain gather round the queen in a cluster, and thus they pass the cold months, not exactly sleeping, but with the fires of life burning very low. Honey from the store-cupboards is

passed from one to another through the drowsy mass, and warmth is kept up by a gentle beat-beat of many little wings.

Early in the year, as soon as the first spring flowers are opening, there are stirrings in the bee-hive. Those workers which have survived the trial of the cold weather start "spring-cleaning" and building new combs. Some sally forth for water and food. The queen-bee rouses herself, and starts to re-fill the endless rows of waiting cradles.

Some of the workers, as we have seen, are able to survive the winter, kept alive by the supplies of food they, or their older sisters, gathered so industriously in the summer months; and so their community is more or less permanent. This is not the case with humble-bees or with wasps. Their colonies break up in the autumn; only the future mothers survive the winter. They rest in holes through the cold season, and when spring comes they start afresh, and found new colonies.

As we have already said, bees have a very keen sense of smell, and they find out certain things, such as the presence or absence of the queen, by this sense. It is also known that they express their feelings by changing their "hum" or "buzz." But we owe to the careful experiments of Professor Frisch a somewhat unexpected disclosure of a "bee language." It is a strange story.

When an exploring bee discovers some flowers affording an abundant supply of nectar, the first thing it does is to take as much as it can hold. Then it returns to the hive, and in a short time some of its comrades appear on the scene. More and more come and go till there are as many bees as the flowers can supply. When the economic ratio is reached, no more new bees come out from the hive. It looks as if the bees recognised that it is unprofitable for their demand to exceed the supply.

These observed facts raise two questions. How is it that the bees "know" when to stop adding to the numbers of collectors who visit the particular patch of flowers? And how do the discoverers of the new feast of honey make their fellow-workers aware of it, and in such a precise way that they rediscover the patch? Frisch experimented with marked bees, and definitely located feasts of honey and

similar food: he was also able to observe what happened when the bees—variously successful—returned to the hive. He has given reasonable answers to the two questions.

When a bee that has sucked to the full returns to the hive, it executes a " round dance " on the comb. This excites the workers resting in the immediate vicinity, and they hurry out to win a similar success for themselves. But when a bee comes home with a very small supply of nectar, it does not dance, and no " new bees " issue forth. Thus it is the dance that tells the hive when a promising source of supply has been discovered!

But how do the new bees find the treasure? Experiments do not confirm the old theory that the discoverer accompanies its neighbours and leads them to the spot. The new bees hurry off by themselves, and begin an energetic scrutiny of the neighbourhood, to a distance, it may be, of half a mile. But though they search diligently, it is not at random. They have a clue, and that clue is a scent. The discoverer, as we may call her, brought home to the hive not only nectar, but a fragrance; and as she danced on the comb her neighbours touched her, and thus got a definite impression of the characteristic fragrance of the promiseful flowers. It is for hints of that fragrance that the new explorers search as they fly eagerly hither and thither.

But what of the rediscovery of flowers that have no fragrance, though plenty of nectar? It may be that in such cases, the new explorers pay no attention to scented flowers; they are aware that it was not from any one of these that their successful sister obtained her abundant meal. But there is another and a better answer. Bees have on their posterior body a protrusible glandular pocket, which produces a characteristic scent, perceptible even by man and at once recognisable by bees. When the discoverers are feeding eagerly at the nectariferous flowers they protrude their scent-organ, and thus spray the blossoms—whether fragrant or not—with the tell-tale odour. This serves as a clue to the new explorers. The two clues taken together work exceedingly well, as well as, or better than, if the

discoverer led her sisters to the very spot. Thus if they follow the floral scent carried by the discoverer, they have some chance of finding other patches of the same species of plant, and thus tapping fresh supplies.

It must often happen that a group of flowers is damaged by bad weather, and then the bee-visits become few and far between. But if the weather changes again for the better, and the flowers pick up again, the good news will soon be told in the hive by a dancing bee. And if there are workers resting on the comb who had previously visited the flowers, they will not lose much time in setting forth again.

What is true of the bees when they are bringing home nectar holds good for those that are collecting pollen. But the " language " will be, as it were, more emphatic when there is a heavy load of fragrant pollen in the so-called " baskets " on the last pair of legs. It is also interesting to find that the dance is different in the two cases. For half a minute or so the nectar-carrying dancer trips in a narrow circle, perhaps a dozen times, perhaps twenty; not always in the same direction. But the pollen-carrying dancer sways her body gracefully and rapidly, first in a semicircle to the right and then in a semicircle to the left, the axis of the swing being immediately in front of the insect's head. There may be four to twelve swayings, and then a rest. The spectacle has a very exciting influence on the bystanders; they come pressing in like sniffing dogs. They are eager for news.

We have lingered over Frisch's observations and experiments because they correct older views that were too generous, *e.g.*, in supposing that the discoverer-bee led her sisters to the feast of honey. At the same time they disclose an intricacy of behaviour, marvellous even when analysed.

HUMBLE-BEES

There is something very attractive about humble or bumble bees. Their furry coats and pleasant colours suggest comfort; their flight is masterly; their industry is a sublime infatuation; the hum of their intensely rapid

wing-strokes (as distinguished from the excited buzz when the breathed-out air vibrates a taut membrane at each of the four breathing-holes beneath the wings) is pleasant to our ears; and they show a restraint in stinging which we wish hive-bees would imitate. But even more attractive is the dramatic interest of their year's life, of which a remarkably fine account is given in Mr. F. W. L. Sladen's *Humble-Bee* (Macmillan, 1912), one of the best of modern Natural History books. What in a few words is the life-story which has been worked out by Mr. Sladen and others?

Towards the end of summer a young queen is attracted by the flower-like fragrance of a drone and is fertilised. Immediately thereafter she seeks for a dry bed in the ground or among moss and thick herbage, preferring a northern aspect where the sun will not waken her too early in the spring. Her torpor lasts for about nine months, and her awakening—when she makes for the willow catkins and other early flowers—is sometimes not very thorough, for she may sink to rest again if the weather be chilly. Once fully awake and well-refreshed, the queen seeks for a suitable nesting-place, such as the deserted burrow of a vole, and this she makes comfortable with fragments of grass, moss, and other soft material, fashioned into a hollow ball. We have heard of one that nested in the spare-room bed-quilt. For the first few times of coming and going, the queen educates herself carefully as regards the lie of the land, so that there may be afterwards no mistake in making a bee-line for the nest.

In the centre of the dry material a snug cavity is made, about the size of a large marble, and in the middle of the floor of this a lump of honey-moistened pollen is deposited and topped with a circular wall of wax. In this cell—about the size of a pea—the queen then lays her first batch of (six to twelve) eggs, sealing them up with a waxen lid. She broods over them all the night and most of the day, and she reduces the number of food-collecting interruptions by making near the entrance to the nest-chamber a delicate waxen honey-pot, about the size of a black currant, in which there is a continually replenished store. All this detailed

carefulness has to do with the future as well as with the present—it makes for success in rearing offspring, and on this success, as Darwin insisted, the survival of a race may in great part depend, especially when the number of offspring is not very large.

In four days the eggs hatch into whitish grubs, which devour their bed of pollen paste, and are also fed, first all together and afterwards one by one, with liquid food which the mother injects at intervals. Each feeding time means cutting a hole in the waxen lid of the cell and closing it up again. On the eleventh day after egg-laying the larvæ are full-grown, and form tough papery cocoons, clustered together so as to leave a median groove in which the queen lies outstretched, trying to keep them warm. Out of each cocoon, about three weeks after egg-laying, there emerges a full-formed, silvery-grey bee. "Her legs are weak and unsteady," Mr. Sladen writes, "and almost the first thing she does is to totter to the honey-pot, where she slowly unfolds her proboscis and takes a sip of the life-supporting drink. Then, refreshed and strengthened, she returns to the brood and nestles under the warm body of her parent." In a couple of days she has her mother's fine colouring, and differs only in size and in being a "worker," a female that does not *usually* become a mother.

The queen proceeds to lay more eggs, which are deposited in cells attached to the sides of the cocoons of her first brood; and as her children increase in number and are able to bring in plenty of food, she settles down entirely to indoor maternal duties. The workers fill up empty cocoons with honey and may make special honey-pots as well; pollen is also stored, by some kinds in vacated cocoons, by others in special waxen pockets. Here we have a far-off hint of the storing instinct of hive-bees. As the comb grows bigger the nest material is pushed out to make room for it, and a waxen canopy or ceiling is often made. The population of workers increases, and through their short life, lasting only about a month, they are busy the livelong day, the younger ones as nurses, the older ones as foragers. All night, too, they are more or less active, building



Photo: John J. Ward, F.E.S.

THE LEAF-CUTTING BEE (*Megachile*).

The solitary leaf-cutting bee, which is about the size of a hive-bee, uses leaves in the making of its cells. Here it is seen at work, the upper leaf to the right of the picture showing two neat curves, from which segments of leaf have been cut off. The bee has a cut-off piece of leaf hidden beneath its body.



Photo: John J. Ward, F.E.S.

CARRYING A PIECE OF ROSE-LEAF TO THE CELLS.

The cells are dexterously constructed of segments of leaf, curved on themselves, and a lid is made of smaller pieces.

and tidying up, feeding and brooding over the young, or ventilating the nest by continual fanning with their wings.

As the weeks go past, the queen begins to lay eggs which develop into drones or males and into queens or mothers. Unfertilised eggs develop into drones; late-laid fertilised

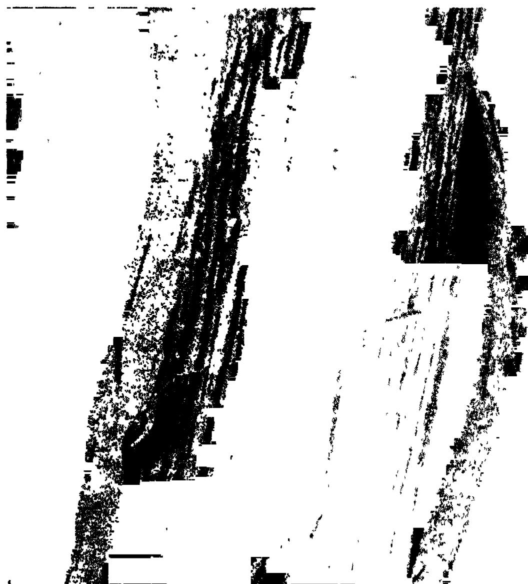


Photo: M. H. Crawford.

THE LEAF-CUTTING BEE—THE CELLS COMPLETED.

The nests are made in holes and the cells are often arranged end to end, as the photograph shows. They are triumphs of instinctive art. Each is half-filled with pollen and contains a single egg.

eggs develop into queens; but it is likely that the food given to the queen-producing larva requires to be somewhat different from that given to the worker-producing larva, which also develops from a fertilised egg. Mr. Sladen observed in the nest of the Stone Humble-Bee that the workers made for a time persistent attempts to destroy the cells in which the queen had laid eggs destined to become

drones or queens. But she eventually has her way. When the young drones are able to fly they leave the nest and do not return. They prowl about for three or four weeks, seeking mates, and making favourite "pausing-corners" fragrant. As the queen ages she becomes bald and tired; she ceases to lay so many eggs; and then it often happens that "laying workers" appear—the virgin mothers of drone offspring. These drones, like other drones, have obviously mothers but no fathers.

A populous nest of the Stone Humble-Bee (*Bombus lapidarius*), the Large Earth Humble-Bee (*B. terrestris*), or the Small Earth Humble-Bee (*B. lucorum*) may have two hundred to three hundred workers and about fifty young queens; while, perhaps, a hundred drones have taken wing. But the numbers vary greatly with the degree of prosperity. Sooner or later, however, all comes to an end; the stores are exhausted and cannot be replenished; the short-lived, over-industrious workers die off; and the queen, though she may rally for a while and renew her youth after she ceases to be so prodigiously maternal, succumbs to brain-fatigue and falls into a final sleep. Only the young queens, hidden in their winter-quarters, are left to continue the race, and if everything goes well they may live to be a year old.

There are not many animals that will say "bo" to a queen bumble-bee, but workers may be found spiked on thorns in the Red-Backed Shrike's hedgerow larder; and the Great Tits share with Bottom, in the *Midsummer Night's Dream*, a liking for the red-hipped bee's honey-bag. But the vulnerable spot in the humble-bee's scheme of life is the nest, well-concealed as that may be. When the queen is from home, a field-vole or a shrew may effect a burglary, and devour the early brood. An invasion of ants may put an end to everything; the caterpillars of the wax-moth can destroy a large comb and its contents in a few days; and there are many other unwelcome intruders. Of great interest is the handsome fly, *Volucella bombylans*, which is a "double" of the worker Humble-Bee, and buzzes like it, and frequents the same flowers. The females lay their eggs in Humble-Bees' nests, and Mr. Sladen notes the

interesting point that even if they are stung to death as intruders " they are always able to finish laying their eggs." The larvæ live in the débris under the comb and seem to be scavengers rather than parasites. It is a strange world with all these entanglements in the web of life.

But the deadliest enemy of all is one of the Bumble-Bee's own zoological household, namely, the strange Usurper-Bee, whose technical name of Whisperer (Psythirus) is suggestive of its soft hum and its underhand ways. This is one of the most remarkable facts about Bumble-Bees that some species have " Whisperer " doubles so like them that only an expert can tell the difference. One kind of " Whisperer " frequents the nests of the Stone Humble-Bee, another is associated with the Large Earth Humble-Bees. They occur as males and females, but there are no workers. The females have no pollen-collecting apparatus, their skin is thick and hard, their sting is stouter and more curved than in Bombus, they are slow and awkward in getting food for themselves, they sneak into the nests of the industrious Bumbles, they sting the queen to death, and get the workers to work for them and rear their offspring. Mr. Sladen notices that the usurper female seems to ingratiate herself with the workers, while the rightful queen becomes strangely despondent. The unequal struggle between rightful queen and usurper seems to be evaded until the intruder is about to lay. The Humble-Bee queen cannot stand *that*, and she does not usually survive to witness it, for the issue of the combat is, according to Mr. Sladen, a foregone conclusion. The " Whisperer " wins. Other observers have reported that there is sometimes a rather ignominious compromise, as the outcome of which the Humble-Bee workers minister to the invaders. It is very interesting to find strong evidence that the " Whisperer " has evolved as an offshoot from the Bumble-Bee race in relatively recent times. It is a rather disreputable new departure ; evolution is not always progress. Perhaps we should mention that the males of the " Whisperers " keep outside this strange tangle, and play about in the flowery meadows, seeking for mates.

The fact in the Humble-Bee's life-history that we wish to emphasise is the contrast between the busy summer life, when there may be two or three hundred bees about the nest, and the tragedy of autumn when all die off or are killed except some young queens that rest through the winter and start fresh families in the early spring.

THE ANT-HILL

Another example of an insect society—in which each member performs certain work for the good of the whole community—is to be found in the ant-hill. Life in an ant's nest has much in common with that in a bee-hive. There are three classes, queens, drones, and workers, each necessary in its own way to the welfare of the community. Work is divided, and each worker must take its share, or, if need be, sacrifice itself for the common weal.

The queen is concerned only with egg-laying, while the workers undertake the duties of foraging, housekeeping, and nursing. When one turns over a big flat stone one often sees ants scurrying away, carrying with them little white objects. These are the young ants in their resting stage, inside the white cocoons they themselves have spun. The ant-nurses carry them to safety, just as, within the nest, they often move them from room to room to secure the proper degree of warmth. When the young ants are ready to come forth as perfect insects, the workers bite open the cocoons.

The foraging ants make a network of roads round the nest as they come and go. They can be seen returning to the home with their loads, and if one of them finds some prize, a caterpillar perhaps, that is too big for her to tackle alone, she will summon her companions to her aid, and together they will try all sorts of ways of dealing with the bulky booty, until they succeed in bringing it in to the nest.

One of the conventions of the ant-community is that if a hungry ant applies to a full ant for food, it must be fed. It is said that if an ant refuses to disgorge a drop of food for another it may be put to death by the other workers !

The ants have many peaceful occupations. They build and they tunnel; some of them cultivate plants and gather their seeds, while others grow a palatable fungus, which they enjoy very much, on specially prepared beds. One of their strange habits is that of keeping pets. A number of other insects are often found in the ant-hill, some of which are merely tolerated visitors while others are apparently welcome guests. Little crickets find food and shelter there—if they beg in vain for food, they will steal it. Minute beetles, too, are often fed by the ants, which yield to their pets' persuasive caresses by sharing with them the sweet substances they carry in their crops. These beetles have a fragrant scent, which the ants seem to like; but some ants carry tiny mites about on their bodies, and feed them, without so far as we know, getting anything in return. The only explanation of their care for them is that they are fond of their pets!

Other little insects found in the nest are "domesticated animals" rather than pets. The aphides, or plant lice, so common on our rose-bushes, secrete a sweet fluid, of which the ants are very fond. For the sake of this "honey-dew" the ants cherish and feed the aphides. They stroke them with their feelers, and lick the sweet juice that oozes from their bodies. They even go as far as to collect and care for the eggs of the aphides, sheltering them through the winter, so that they may keep up their supply of "cattle." Some of them make little "cattle-pens" of earth, where they keep the aphides, all ready to be "milked" of their honey-dew.

Some kinds of ants have different types of workers, for example, one species has workers which have taken upon themselves the rôle of "honey-pots" for the community. In the nest there are grotto-like chambers, in which these individuals hang from the roof. These ants live in dry hot parts of North America, and they collect a sweet juice that is found for a short part of the year on the surface of a common variety of gall. When they return to the nest laden with this "honey," they pour it into the bodies of their passive comrades, till the "honey-pots'" crops are

so full that the whole abdomen becomes round and swollen, with its covering plates far apart. "When the yellow colour of the honey shines through the thin stretched skin of the spaces between the plates these singular creatures look almost like Japanese lanterns hanging from a domed roof."

Inside the ants' nest harmony seems to reign; no insects seem better to have learnt how to live together in a mutually helpful way. But the battles of ants are also famous. For while "the little people" are seldom aggressive when alone, they have the instinct of combined attack, and often carry out well-organised warlike expeditions. The ants of two different species sometimes become mixed up in an ill-natured turmoil, confusion seems to be the order of the day, yet every ant seems able to recognise those of its own band.

Many plants shelter ants in little holes and crevices. Sometimes the guests pay their way by keeping the plant free from destructive fungi. When a band of leaf-cutting ants comes to an ant-protected plant, the resident ants rush out to ward off their attacks, and fight the invaders vigorously until very often they are forced to beat a retreat.

Some of the workers among the leaf-cutting ants are "soldiers," large, round-headed, and one-eyed, with specially strong jaws, well-suited for doing battle. Their grip is so firm and unrelaxing that the Indians are said to use them for stitching wounds. They let the soldiers bite the edges of skin together, then snip off the bodies. Even death does not unclench the powerful jaws.

A distinguished observer, Mr. Beebe, has described the habits of the Army Ants, which make a contraption of their living bodies, linked together, with countless jaws always in readiness to resist intrusion. Mr. Beebe, at the cost of some fiery stings, spent many hours watching the life of the colony. The entrance of the contraption was guarded by a mat of ants, which made a living archway through which others had to pass. When the soldiers returned with a load, they handed over their booty, and then submitted to being thoroughly scraped and cleaned by a group of workers.

The colony was broken up by spraying it with formol. The ants unlinked themselves and moved off, carrying their young ones with them. Some remained near by for a day or so, tending those of the young which were passing into the pupa stage. They were seen gnawing wood into shreds to make a light covering for the young, which then began to spin cocoons. After a short time they all disappeared.

Sometimes the expeditions of the ants take the form of a raid on the nest of some smaller species of ants, for the purpose of capturing slaves. The prisoners are always babies and children, which are carried back to their captor's nest. After a little they emerge as workers and share the work of the colony.

Different kinds of ants show different relations with their slaves. In some cases the masters can manage quite well by themselves if need be, though they usually keep slaves to share their labours ; but in other cases there is a price to pay for stealing their neighbours' children. The ants become so dependent on their slaves that they forget how to fend for themselves, and if their helpers refused to feed them they would die of starvation.

The Amazon ants cannot live without slaves. They seem to have lost every peaceful accomplishment. They cannot dig or tunnel ; they cannot tend the young ; they cannot even forage for their own food. They are soldiers, and soldiers only. Their jaws are suited for killing, and not for ordinary toil. When they are at home in the nest they pass the time cleaning and polishing their shining brown bodies, or begging for food. Their slaves seem to be willing helpers, ever ready to put food into their mouths. A life of ease, indeed ; but what a contrast when the Amazons go forth to battle ! Then they are intrepid warriors, resolute, courageous, and precise. They have an extraordinary gift for combined action, which makes their raids very successful.

Experiments made by Professor Emery showed how instinct had its way. He put an Amazon queen into a colony of Brown ants. She immediately killed the Brown queen, and took her place, and in course of time there was a mixed colony, consisting of Amazons, which had never been

outside the nest, and a number of Brown ants, which acted as slaves. They waited on the Amazons, but they also kept them indoors as long as they could. After a time, however, the Amazons became more and more restless, and finally some of them escaped and set out to explore. One scout found a nest of Brown ants, and promptly raided it, returning home with a captive—a cocoon, a new slave in its infancy.

Later on, after scouting had gone on for some time, an organised raid took place. Sixty Amazon ants made a sortie, and attacked a neighbouring colony of Brown ants. They did not give up their raiding expeditions until they had carried off 450 prisoners. On another occasion, the raiders kidnapped over a thousand slaves in less than two hours. One cannot quite admire the habit of capturing children and making slaves of them, but there is no denying that the Amazon ants do it very successfully.

AS REGARDS ANIMAL ARCHITECTURE

Many animals show great architectural skill. Some build "homes without hands" and ramparts for defence; others make cradles for the young; others construct store-chambers for food; and various purposes may be served by the same building. The Bower-Birds build bowers for their amusement. Some Caddis-worms fashion beautiful traps for catching small water animals, and the spider's web might also be included under architecture.

Very common in warm countries are the hills of the termites or white ants, which illustrate very well what we mean by animal architecture. They are dwellings for large families or communities, and they sometimes contain several thousand inhabitants. The insects themselves are nearer to dragon-flies than to true ants; indeed termites and true ants are as different as different could be, except that both are social. The termite community includes a royal pair, the female or queen and the male, the great body of workers, a large number of soldiers, and also reserve males and females, which are kept in readiness to replace

the reigning pair if any accident should occur. A common length for a worker termite is half an inch.

The termitary is usually made of earth and wood. Sometimes the earth has passed through the insect's food canal, sometimes it is simply chewed and mixed with fluid. It often becomes as hard as stone. The wood is also chewed and cemented. In many parts of South Africa the termite-hills are as thick as molehills on a badly infested field; they are often a yard in height and strong enough to bear a man's weight. In the wilder parts they are often much higher.

The greatest building achievements among termites are the erections made by the so-called "compass ants" or "meridan ants" of Australia. They are often ten feet high, and occasionally double that, triangular or wedge-like in cross-section. But the most remarkable feature is that they all point the same way, the long faces running north and south, the triangular gable ends turned to the east and west.

A mound sixteen feet in height may be built by termite-workers a fifth of an inch in length. Professor Houssay points out that the Eiffel Tower was 187 times the average height of the workmen who built it, but the termitary may be 1000 times the height of the worker termite. To equal the termitary in proportion, the Eiffel Tower (1000 feet high) would have to reach a height of over 5000 feet.

But the details of the termites' buildings are as interesting as their dimensions. In the case of the Warrior Termite (*Termes bellicosus*), described by Houssay, the dome-shaped dwelling may be ten feet high and its walls may have a thickness of two feet at the base. A huntsman sometimes climbs to the top to get a good view all round. There are passages running through the walls, giving entrance to the various levels, and there are staircases winding up to the summit. The former are used every day and every night for going out and coming in; the latter are used by the builders in carrying earth. In the ground below the termitary there are holes, like quarries, from which the earth was dug. They may afterwards serve as cellars and as catacombs.

On the ground floor there is the royal chamber, where the bloated queen lays eggs at a great rate. Round this are

rooms for the attendant workers and the bodyguard of soldiers. Farther away there are store-chambers with particles of vegetable gum and other reserves.

The first floor is a spacious hall supported by earthen pillars, which may be a yard high. The second floor is a great nursery, where the young termites are reared in little pigeon-holes made of chewed wood. The walls of the nursery are covered with a glistening fungus, which is used as food. The top storey is a well-ventilated empty attic. Plainly, it is a well-designed house.

In Jamaica and some other countries there are termite "nests" fixed on trees, and connected by a gallery with the main dwelling underground, and by other tunnels leading to the top of the tree—for termites have a deeply rooted objection to facing the light of day. This kind of erection, made of very minute wood particles glued together with saliva, varies in size from a man's fist to a hogshead, and may be described as an "annex." There is a firm outer wall and many compartments in the interior. It is *a hanging house*, and from it we may pass to the wasp's nest.

Some wasps always build underground, as is the case with *Vespa vulgaris* and *Vespa rufa*; others build always in the air, hanging their nest to a branch, or inside a hollow tree, as in the case of *Vespa norvegica*; others, like *Vespa sylvestris*, try both situations. But we shall keep to the familiar hanging house, which may vary in size from a Tangerine orange to a bandbox.

The house is made of a kind of paper or wood-pulp, and the wasps plane off the material from the posts and palings and bare tree stems. A central support is fastened to a branch, and on it there is hung the first storey, which carries a number of cells or cradles on its down-turned surface. From the middle of this, the central support is continued downwards and bears the second storey. Below this a third is built, and so on. Besides the central support fixing storey to storey, there are extra beams, also running vertically from one level to another. Then over the whole series of stories there are numerous—sometimes over a dozen—

umbrella-shaped overlapping envelopes of the same papery material, waterproof and wind-proof, and all very light. The temperature within may rise to 30° F. above that of the surrounding air. An entrance is left open at the foot. It is plain that there are some good ideas in the wasp's nest—a paper house, a hanging house, a house of many storeys, a house well sheltered from rain and wind!

There are some details that are of great interest. Thus as one storey or comb is added after another—seven is a common number—and as the cells come to contain grubs, the weight is greatly increased, and there is a strengthening of the original support up at the top. Only the beginning of the edifice is the work of the mother-wasp or queen, for after she has made the original fixture and part of the first comb and several umbrella-like envelopes, she has worker offspring ready to do their part, and to them all the rest of the building is due. As the comb is broadened out by adding new cells round the margin, the innermost envelope is cut away and a new outermost one is put on. This is always going on. In adding wood-pulp to an envelope to increase its size the wasp stands on what has been already made and retreats along the margin so that it does not step on the soft material.

As to the population, it may be noted that in the underground nest of *Vespa germanica*, the French naturalist, Charles Janet, counted 11,500 cells on seven combs. Over 11,000 had been used twice and about 5,000 thrice. In his valuable book on *Common Animals* (1904), Mr. Oswald H. Latter calculates that a large nest of ten or eleven combs might have a population of 50,000 or 60,000 wasps. But of all the multitude only the young queens survive the winter. That is the tragedy of the hanging house!

There is little among ants to compare with the hanging house that wasps make or the great tower that termites build, but there are some interesting achievements at a lower level. The ants' nest is often a mine excavated in the earth by a multitude of jaws. The entrance to the shaft is sometimes surmounted by a turret or a dome, which helps to keep the underground dwelling warmer. There is an

extraordinary Indian nest, where the vase-like turret is surrounded by six to eight circular ramparts, the outermost nearly a foot in diameter.

The underground dwelling is often more like a city than a house. Thus Professor Forel studied one in Algiers, which had half a dozen openings, like the craters of volcanoes in shape, at intervals of three to ten yards, and all connected by an underground passage, running at a depth of about five feet. He estimated that the whole excavation must have extended over fifty to a hundred square yards. Corresponding to each " crater " there was an underground granary, but it was all one vast nest, inhabited by a single community. The grains of sand are carried out in the jaws or entangled among special hairs about the mouth.

Many ants with underground nests may be found sheltering under bark or in decaying stumps that are dry. They may make galleries and chambers out of the wood-dust. Sometimes they have arboreal stables in which they keep their " cows "—the Aphides. When the autumn comes the cows' calves are often taken underground for the winter, and the eggs they lay are cared for by the ants.

But there are special tree-ants which make elaborate tunnels. There is a little doorway in the bark, a straight passage through the sapwood, which they do not injure, and then a maze of passages, up and down and crossways. The tunnels may be so numerous that the tree gives way in a storm, and the same thing may happen to the wooden support of a bridge or of a hut. Of course these tree-boring true ants must not be mixed up with the termites.

Some ants make papery nests of wood-dust, cemented with the juice of the mouth, and sometimes eked out with fibres and the like. Inside the nest there is often a velvety growth of a black mould which the ants are fond of eating. Paper nests are usually about six inches long, but they may reach two feet, and Forel describes big ones in the Brazilian forests that hang down like stalactites in a cave, or, when they are covered with drooping threads, like the beard of some great giant among the trees.

The well-known tailor-ants of warm countries unite in

small companies to draw leaves together, but the problem is how to fix them, for the full-grown ants have nothing that will serve as glue. While some of the workers hold the leaves close together, others fetch the young ones which have a sticky secretion in their mouth. A worker-ant holds a grub in its jaws and dabs it against the leaf, as if it were a gum-bottle. The fine sticky thread from the mouth of the larva fixes the leaves together. This is a unique case, the young ones aiding passively in the labours of the adults. So much for architecture among ants!

BUTTERFLIES

Butterflies are among the most delicate of living creatures and strike the three notes of beauty—in their form, in their colours, and in their movements. They express the idea of summer not least in this, that the winged adults are mostly preoccupied with "love" and very little with "hunger." This is another form of the contrast between foliage and flowers; and there are some butterflies which never eat at all. The explanation is, of course, that the big appetite of the caterpillar makes the gay life of the butterfly possible. As Shakespeare says: "Your butterfly was a grub"; and this particular contrast is but a particularly vivid instance of a see-saw that can be discerned throughout the world of life, the see-saw between "hunger" and "love," between nutrition and reproduction. It is in a way the see-saw between caring for self and caring for others.

The familiar grouping of Lepidoptera into moths and butterflies seems to be more convenient than scientific, but most butterflies have a knob at the tip of the feeler, which is rarely the case in moths; and in the great majority of moths there is a special bristle arrangement for hooking the front of the hind-wing under the posterior margin of the fore-wing, a contrivance not found in butterflies, though here also there is a combined action of the two wings on the same side. There is not much in the familiar distinction that most butterflies are active by day and most moths by night.

Very characteristic also is the fact that the mandibles or jaws which mean so much in most insects—and so much in the caterpillar!—are usually indistinguishable in the butterfly, though minute dwindling vestiges are sometimes discernible. But a portion of the maxillæ, that is to say, the second pair of mouth-parts, is greatly developed to form the spirally coiled proboscis. This is a beautiful structure, with all the marks of efficiency; yet in many butterflies it seems to be of very little use. The probability is that in ancient days, before the task of accumulating nutritive reserves was laid so completely on the shoulders of the caterpillars, the adult butterflies had themselves to do a good deal of nectar-sipping to keep body and soul together. This may account for the elaboration of the proboscis in those present-day butterflies that are often hardly nutritive at all. Even among those that dally with flowers the amount of nectar ingested is often trivial. Hunger is over, love is ascendant. We are not denying that the proboscis is sometimes part of a really important suction pump; our point is simply that for many butterflies feeding is quite unimportant. They make love and become parental on the strength of having once been caterpillars. In short, they live on their past.

This is far too cold a way to speak of butterflies, for they are unsurpassed in their combination of beautiful colours, beautiful forms, and beautiful movements. One cannot but believe that they give us a joyous glimpse of something as much in the heart of life as the see-saw of colloidal metabolism. Is there not a glimpse of the butterfly's sub-personality in man's unusually happy way of naming many of his butterflies; there is a charm in such titles as the Purple Emperor, the Red Admiral, the Painted Lady, the Peacock's Eye, the Green Fritillary, the Lady of the Woods, the Swallow Tail, and the Aerial Blue.

The total number of British butterflies is probably sixty-six, and ten of these are only visitors, like the Camberwell Beauty, which cannot find a permanent footing, perhaps because of adverse climatic conditions, perhaps because of the absence of suitable food-plants.



Photo: John J. Ward, F.E.S.

PAINTED LADY BUTTERFLY ASCENDING THE STEM IN READINESS FOR FLIGHT.

The Painted Lady (*Pyrameis cardui*), predominantly tawny orange but exquisitely marked, is a relatively rare North African immigrant to Britain. It often flies late in the day, when other butterflies have gone to rest.

The coloration of many animals, take lobsters for instance, is due to pigments; but in other cases, like the inside of the mother-of-pearl oyster, there is no colouring matter at all, all the rainbow hues being the result of physical structure, as pounding a piece of shell at once shows. For it becomes white chalk! But the finest colour effects, such as those of butterflies and humming-birds, are due to a combination of pigments with fine surface sculpturing. The beauty of the pigments is enhanced, one might almost say transfigured, by the fine lines and layers on the surface. Thus the scales on a butterfly's wing are covered with microscopically fine lines which give rise to the iridescence. There are many blue butterflies, but there is no blue pigment. The combination of pigment-colouring and structure-colouring is often so beautiful in butterflies that one thinks of them sometimes as flying flowers.

Just as the male mosquito can find the female from some distance when she produces her shrill note, so some male moths can find their mate from a mile off by help of the characteristic fragrance which they emit. Among the butterflies that are fragrant, however, it is usually the male that gives off the scent, and observations have proved that this is attractive to the desired mate. The fragrance is produced by skin-glands; it often oozes out by fine pores or accumulates in a little pocket. Much more than this has in some cases been described—namely, the presence of minute reversible brushes with delicate hairs which allow the scent to diffuse into the air. The brush may be at the end of the tail and the scent-glands on the wings so that the butterfly has first to sweep his wings; and an extraordinary detail is that in certain cases there are "dust-filaments" in the brush-bag which readily break up into fine perfumed dust which is scattered in the air. As Dr. Eltringham says in his delightful *Butterfly Lore* (Oxford, 1923): "The apparatus is really an animated powder-puff." This expert advises those interested to catch a male of the "Green Veined White," a common spring butterfly, in order to verify the distinctiveness of the fragrance. In this species it is like lemon-verbena. It should be noted here that butterflies

of both sexes have often repellent odours, which are probably in most cases protective against enemies.

Butterflies are exquisitely sensitive creatures, quivering to many different kinds of environmental stimuli, but it seems that the use of the sensory receivers is rather to pull the trigger of certain actions than to give the butterfly information about the outside world. Only in the higher animals do the senses come to be very important as the gateways of the mind.

The sense of smell, which we have noticed in connection with butterfly courtship, is probably located in the knobbed antennæ, which have also to do with effective flight ; the sense of taste is often near the mouth, but in the Red Admiral, which has a very sweet tooth, it is mainly in the feet ; the sense of touch is at strategic points in many regions of the body. Some moths produce sounds, but this is very rare in butterflies ; and even when there is a sound—a sort of instrumental clicking—it is difficult to prove that it is heard.

When we speak of smell and the like in butterflies, we must not suppose that their senses are much the same as ours of the same name. This is very obvious in the case of vision, for the butterfly's eye is utterly unlike that of man. It is fixed and lidless ; it consists of thousands (five thousand in the Tortoise Shell) of eye-elements, each complete in itself, with cornea, lens, and retina ; it is extremely shortsighted, having a range of only a yard or so. The image formed in the recesses of the eye is an erect image, not inverted as in our case. Besides image-forming, there is, in some degree, a discrimination of colours. But butterflies do not see the world as we do !

The eggs of many butterflies are remarkable in their decorativeness. Butterflies have been flitting about for perhaps three million years, is it surprising that they should now be perfect works of art ? And the egg is the living creature in the one-cell phase of its being. But this is only one of the many butterfly puzzles. What living hand of the past is upon the mother butterfly that she lays her eggs, often singly, on the one and only kind of plant that



Photo : By courtesy of the British Instructional Film Co. Ltd.

YOUNG CATERPILLARS OF THE LARGE WHITE BUTTERFLY.

Hatched out from the eggs in about a week after laying; they become greenish, with blue or grey above.

the caterpillar can use as food ? And how are we to think out the way in which development begins afresh in the quiescent chrysalis stage, on a new architectural plan so that what fell asleep a caterpillar awakens a butterfly ? This is a big puzzle indeed.

CUCKOO SPIT

One of the most familiar sights in early summer, in June let us say, is the " cuckoo-spit." In the fields and by the wayside and in the garden, on many different kinds of plants there are curious splashes of white froth. There seems to have been an old idea that when the mother-cuckoo goes about in spring looking for the nest of a meadow-pipit or of some other bird in which to place her own egg, she spits and spits every here and there ! But no one who cares to look can any longer believe that " cuckoo-spit " has anything to do with the cuckoo.

Let us try to understand something of the natural history of " cuckoo-spit," keeping especially to the particular insect, *Aphrophora spumasia*—one of the commonest kinds. Where does the insect come from ? How does it make the foam ? What is the meaning of the foam ? What becomes of the creature later on in the year ? It is only fair play to have the answers to these questions before us before we call the cuckoo-spit repulsive. We must remember the lesson St. Peter learned on the housetop, which warned him not to be too quick in calling any living thing " common " or " unclean."

The life-story for the year is something like this. In the autumn the mother frog-hopper, an active insect approaching half an inch in length, lays her eggs in deep crevices in the bark of willow-bushes or the like, and soon afterwards dies. The eggs hatch in the spring, and there emerge little green larvæ with the body flat below and pointed behind, with a head bent down upon the breast, with a sharp, piercing beak well suited for penetrating the skin of young leaves, and with the usual three pairs of legs well suited for taking a firm grip of the plants. If one puts the creature

on a clean leaf and watches it through a good pocket lens one sees it probe with its beak, which consists of sharp needles inside a green tube-like case. By means of the beak the young larva sucks up the sugary sap of the leaves, just like its relatives the green-flies or Aphides. And just as "honey-dew," as it is called, passes out of the green-flies in large quantities and smears the leaves, or even falls like drops of rain to the ground, so the surplus sap passes through the food canal of the frog-hoppers and forms the familiar foam-like "spit."

Along the posterior region of the frog-hopper's body there is a ventral runnel in which air can be held, and the sap-sucker works this up and down until the captured air gets thoroughly mixed up with the surplus sweet fluid, which passes out of the food-canal. Just as the cook makes "whipped egg" by beating air with a spoon into the "white of egg," so this insect makes whipped sap. As it does so there is added a little wax from glands on the skin and a little ferment from the food-canal; and there is a beating up of the four things together—sugary sap, air, wax, and ferment—and the result is what may be called a soap—the cuckoo-spit. If it consisted only of bubbles it would soon disappear in the heat of the day, but, being something like a soap, *it lasts*; and this keeps the young insect moist. Moreover, very few enemies will touch the frothy mass, except an occasional wasp, which is not daunted by anything. So here is an insect that saves its life by blowing soap-bubbles!

The food is very abundant and the insect grows and moults, and grows and moults again. Finally, it passes into a resting or pupa stage; its wings grow, and other changes of structure are brought about; it leaves the froth and moults for the last time; then it becomes a full-grown winged insect, and there is no more foam to be seen on the herbage. Every one must have noticed that what is so abundant in the early part of summer disappears altogether later on. All the frog-hoppers have grown up. Yet as late as the first week of August we have seen plenty of "cuckoo-spit" in some of the valleys of the Cairngorms.

They say that it was Isidore, Bishop of Seville, who started the name " cuckoo-spit " about 636 A.D., and to him it was very wonderful that from within a fleck of froth there should arise a singing insect, namely, the singing cicada. Now he was wrong in thinking that the little frog-hopper became a cicada, though they are certainly cousins ; he was wrong in supposing the cuckoo had anything to do with it ; and he was most of all wrong in supposing that the froth made the insect, for we know that it is the insect that makes the froth. We know nowadays, thanks to many keen eyes, much more about frog-hoppers than the old Bishop, yet for all that the " cuckoo-spit " is not less wonderful to us than it was to him. Is it not a remarkable device, living under water and yet in the open air, conspicuous and yet concealed, in the sunshine and yet cool !

GLOW-WORMS

As an example of what we may call the *by-play* of the animal body, we may take the luminescence of the glow-worm, which we see on summer evenings. The glow-worm is a small beetle, first cousin of the fireflies and the American " lightning-bugs." The female is wingless, but it is she who produces most light. She is about three-fifths of an inch long, while the winged males does not attain to half an inch. It is in the warm summer evenings that the females shine in their " dells of dew," sometimes climbing on to stems and displaying their lights in different directions, probably to catch the eyes of the males who fly about. We know a mossy bank where the road skirts a damp wood, and on a summer night we have seen scores of " fixed stars " or females among the herbage.

The " wandering stars " or males are not so noticeable. Both are hidden during the day. Like many full-grown insects they live for love, and do not seem to care for food. But it is very different with the young glow-worms, for they have a big appetite and are keen to attack small snails, which they deal with in a way of their own. They seem to inject a paralysing poison with their bite, and they make

the snail's flesh so soft before they swallow it that their meal is practically fluid. Since the larval glow-worms feed chiefly on small snails, and since these frequent moist and shady places, we understand the habitat of the full-grown insects.

The seat of light-production in the female glow-worm is in two strata of cells at the hind end of the body. The cells are not unlike those of the "fatty body," a common reserve-tissue in insects, and they are traversed by fine branches of the air-tubes (or tracheæ) that take air to every recess and tissue of the insect's body. In most animals the blood goes to the air (in the lungs, for instance), but in insects the air goes to the blood. There is no doubt that oxidation has to do with the production of the "glow," and it is recorded that the light becomes more intense when the insect is put into a vessel with an extra percentage of oxygen. It is highly improbable, however, that the light-production is the outcome of mere oxidation. There is strong evidence in support of the theory of Professor Raphael Dubois, corroborated by Professor Newton Harvey, that a fermenting substance in the blood, called luciferase, acts on a light-producing substance, called luciferin, in the cells of the luminous patches. That the fermentation of luciferin by luciferase is accompanied by a rapid oxidation is highly probable.

There is a rival theory, that the luminescence is due to internal nests of luminous bacteria, like those we see on dead fishes. This is probably the correct explanation in some luminous animals, but experts say that it should be ruled out of court in the case of glow-worms and fire-flies. It need hardly be said that "living lights" have nothing to do with phosphorus; so the word phosphorescence should be dropped in this connection. Of great interest is the fact that the light-production of fire-fly and glow-worm is in a sense the most perfect light-production in the world, for the light is "cold light," without any heat-rays. None of the chemical energy is lost in the form of heat. We wonder, then, if "glow" is the right word for the glow-worm's light.

The glow-worm spends the winter in the larval state, hiding itself in deep recesses. It becomes active in spring and hunts for snails. As in its relatives, the form of the body strongly suggests that of the wood-louse, which is, of course, a crustacean that has wandered from its ancestral home in water and become terrestrial. The light of the larva is faint, and as it is turned towards the soil it is not readily noticed. After a period of great activity and keen appetite, the larva becomes a pupa, which is also slightly luminous. The pupa is not so thoroughly quiescent as most pupæ are, for it can push itself along the ground. Metamorphosis is taking place, but in the life-history of the female the change is not conspicuous, for the full-grown female retains the appearance of the larva—an unusual state of affairs.

The winged males pair with the wingless females, and the fertilised golden-yellow eggs are laid in early summer among the moss or moist grass. They soon develop into larvæ, which hunt for snails and accumulate sufficient internal stores to keep them alive through the winter. We suppose that the full-grown insects die after they have secured the continuance of the race. The fact that the eggs, larvæ, and pupæ are faintly luminous, and that only the females of our *Lampyris noctiluca* can glow to much effect, seems to indicate that the luminescence is a sort of chemico-physical by-play of the ordinary routine of the life, and that it is of no use in the early stages at least. In the perfect female, however, it is probably an important love-signal and it must be noted that in many relatives of our glow-worm the males are the more brilliant and have very fine eyes. All the dancing fire-flies that one sees in Italy; for instance, seem to be males; the rare females sit among the herbage. Flashes of light pass to and fro till each female has attracted a little levee of suitors. Finally there is some sort of "choice," and mating occurs.

Some observers have seen full-grown glow-worms eating minute pieces of green plants and also rotten fragments. In some cases they have been observed enjoying particles of sugar. But the general opinion is probably correct,

that the adults take almost no food. It is very different with the larvæ, which devour small snails. Professor Bugnion agrees with Fabre that a poisonous secretion is injected from the jaws into the snail, and that this serves to "chloroform" them. According to Miss Kathleen Haddon a dark fluid is injected through a canal in the glow-worm's mandibles, but she does not admit that there is a preliminary anæsthetising. There is still much to be discovered in regard to glow-worms, but natural history has made progress since the days when they were said to be "generated of dew."

DEATH-WATCHES

The Death-watches are little beetles, with a good many characters that make them what is called "ken-speckle" or readily recognisable. The one we know best is not the true Death-watch but a near relative called *Anobium domesticum*, also given to burrowing in old furniture. It is under a sixth of an inch in length, dark brown in colour, somewhat cylindrical in build of body—as if suited for working in tubular burrows. The feelers are long, especially in the last three joints; the legs can be tucked away under the body; and the hard wing-covers, hiding the relatively large wings, are marked by longitudinal furrows and by very short-set bristles, like much worn pile. Perhaps the most striking feature is the way in which the head is bent downwards under the shelter of the hard foremost ring of the thorax (let us say "breast-region"), which has the shape of a coal-scuttle bonnet. We suppose that the beetle, when at work within the wood, gnaws with its jaws, and presses forward with its coal-scuttle at the same time. The technical name is, as we have said, *Anobium domesticum*, and it is a second cousin of the true Death-watch (about a third of an inch long), *which used to bear the same designation.* There are many other relatives, such as the smaller Furniture Beetle (about an eighth of an inch long), whose larvæ make the familiar tunnels in "worm-eaten" tables and chairs. It has given its name to a human occupation, for the lady

in the police-court deponed that her husband was a "worm-eater"; meaning, of course, that he was employed to make holes in "faked" old furniture. It should be noted that the bulk of the boring is done by the larvæ, and also most of the eating; besides, of course, all the growing. For a beetle never grows after it is a beetle.

An interesting feature in Death-watch beetles is the immediate "death-feigning" whenever we shake the tray or piece of wood on which we watch them. Even a slight

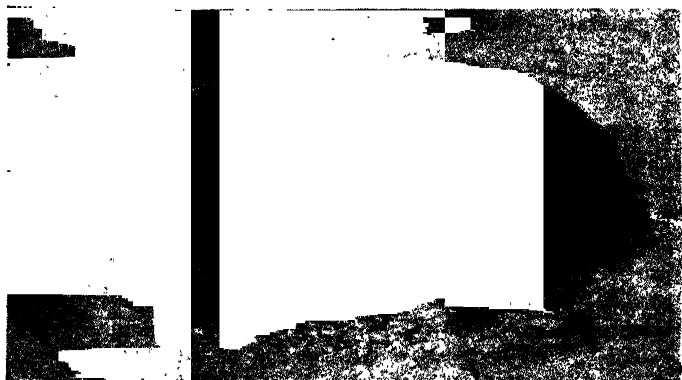


Photo: John J. Ward, F.E.S.

DEATH-WATCH BEETLE (*Anobium domesticum*), SHOWING THE HEAD-HOOD.

The tapping of the male Death-watch is a signal to his mate. The sound seems to be produced by knocking with the front of the thorax, which overlaps the head like a coal scuttle bonnet. But some observers say the beetle taps with its jaws.

jar or a jerk with a needle is enough to send them into this strange cataleptic state. At this low level there is no question of deliberate playing 'possum, as a fox might do; everything points to a racially established tendency to a sort of fit or catalepsy. The inborn tendency works without deliberation whenever there is a threatening jar. When a natural enemy, such as a woodpecker, is on the search for food, the unconsciously wrought-out policy of the Death-watch beetles is to "lie low and say nuffin."

It may be mentioned that there are other entirely different

Death-watches belonging to the family of book-lice (Psochidæ) in the dragon-fly order Neuroptera. Thus there is the tiny wingless *Atropos divinatoria* that runs about among old books and in collections of insects. It is a soft, delicate creature, but it seems to produce an often-repeated tick, which is rather puzzling and should be reinvestigated.

The wood-boring *Anobium domesticum*, with which we started, has a straightforward life-history. Out of the eggs, laid in the tunnels, there emerge minute white grubs, with a soft body, a hard head, and three pairs of legs. They chew the wood with their jaws, and seem to thrive on their dry-as-dust diet, for they grow and moult and feed and grow and moult. No one ever sees them without making excavations, for they lie in the recesses of their burrows. Eventually they sink into the quiescent pupa stage, wrapping themselves up in a silken cocoon with which particles of sawdust are interwoven. The great change occurs, and out comes a small beetle, pale and flabby. It rests a while, becomes hard and brown, and then it goes a-roving. The same kind of story is true of the shorter, broader, and paler *Anobium paniceum*, which is almost omnivorous. It is fond of edible commodities, but it prefers them hard. Ships' biscuits are best of all, but it has been known to eat pictures and herbaria. It is Captain Marryat's "weevil," but it is not a weevil. It is also one of the "book-worms," which are not one, but many.

The Death-watch proper used to be called Anobium, but its name when we looked at the register last was *Xestobium tesselatum*. It is a first cousin of *Anobium domesticum*, but it is a broader, stronger creature, nearly twice as long, and reddish-brown in colour. The tapping is louder than in in the previous case, and it is particularly loud at night. Of a truth, however, it speaks not of death but of love, for the tappings are signals between the sexes, and commonest at the breeding season about mid-summer. They can be evoked sometimes by tapping on the wainscot or furniture with a pencil, for then the Death-watch answers back, four or five ticks being the rule. The creature raises itself on its fore-legs and bobs its head up and down, striking the wood

with its jaws according to some, but mainly, we think, with the front of the breast-region or thorax. The famous Dutch naturalist, Swammerdam, who worked during the latter half of the seventeenth century—a great time for zoology—suggested the name Sonicephalus, or "Noisy-headed Beetle."

As to the superstition which regards the tapping as a presage of approaching death, it must be remembered that the cause of the insistent sound was unknown until about the time of Swammerdam. In his *Household Insects*, to which we are indebted, Mr. Edward A. Butler quotes from one of the earliest descriptions, a paper in the *Philosophical Transactions* for 1698 by Mr. Benjamin Allen. "The second animal I observed is a Death-watch: I have taken some before this, it is that which makes a noise resembling exactly that of a watch: it is faithfully the very same, and lived four days with me, beating exactly, for I took two, I suppose one was the female, that is only conjecture." Punctuation was without subtlety in those days! "This small beetle . . . being rarely heard, and not known, has obtained the name of a Death-watch, which yet I have known to be heard by many, when no mortality followed, and particularly by myself, who have taken two of them, seven years since, without my death following that year." We must leave it at that!

In recent years an interesting light has been thrown on the puzzle of the Death-watch's diet. The grubs, like those of the Anobium with which we started, grow slowly for about three years, but they are from first to last plump, well-fed creatures, though their diet is very unpromising. Especially in the case of the larvæ of biscuit-loving *Anobium paniceum*, which have, however, a wide range of appetite, it has been shown that part of the food canal contains an abundance of partner yeasts, which are able to ferment at least some of the hard stuffs that are eaten. So the food of the larval Death-watches is not so dry as it seems. In most cases of insects with partner yeasts the transference from generation to generation is brought about by the early infection of the egg itself; but in the Death-watch the

method is quite different. The larva, in biting its way through the chitinous egg-shell, becomes infected with yeast-plants which were entangled on the rough outer surface of the eggs when these were liberated by the mother-beetle.

We must not leave the Death-watches without answering the natural question: How can one get rid of them? Perhaps the best plan is to drench the woodwork with *carefully used* poisons, such as corrosive sublimate, carbolic acid, and formalin; to polish with benzine every day till the beetles are gone; to tie cloths saturated with paraffin round the furniture and expose the articles in the open air for many days; to fumigate the room repeatedly with sulphur. But who is sufficient for these things?

"The eye sees what it brings with it the power of seeing," and the naturalist who has learned to peer or "scrutinise," as Fabre used to say, observes twice as many creatures as the casual onlooker. Yet without probing and sifting, even the naturalist detects only a fraction of the animal population of any area, whether it be a corner of a British wood, a shore-pool, a Tropical jungle, or a quiet reach of the river. One reason for this is the frequency of the elusive or "cryptozoic" habit. For many creatures the only chance in the struggle for existence is to make themselves scarce.

GNATS

There are about a score of different kinds of gnats or mosquitoes in Britain, including the Dapple Wing, which carries and disseminates the malaria germ in such countries as Italy. It used to do the same in some parts of Scotland, as the hospital records show, for "ague" is just another word for malaria. If numerous malaria patients should come to Britain, as a number did after the war, the Dapple Wing mosquito (*Anopheles maculipennis*) might resume its rôle as a distributor of the disease in this country.

But we wish to tell the story of the commonest British gnat (*Culex pipiens*), often called the Grey Gnat or the House Gnat. It is a delicately built, long-legged, clear-winged insect, about one-fifth of an inch in length of body.

In typical specimens the second ring behind the head is reddish above, and there is a good deal of yellow on the hinder parts. These two colour characters may serve to distinguish the Common Gnat from its many relatives; moreover it is the only European species that is given to flying about houses.

The buzz of the gnat is twofold. The deeper note is due to the rapidity of the wing-strokes, of which there are many hundreds in a minute. But there is a shriller note, apparently confined to the females, which is due to the vibration of tense membranes at the openings of some of the anterior breathing-tubes. It was shown long ago that if the same note is produced artificially, by means of a tuning-fork, in the vicinity of a tethered male he exhibits a sympathetic quivering of his bushy feelers. By automatically adjusting his body so that the two feelers are equally stimulated the free-flying male is likely to find the clamant mate; if he gets off the line in his flight a fresh adjustment occurs. But in some cases at least, the females spontaneously join the swarms of buzzing males.

The usual food of the gnats is the sweet juice of flowers and fruits, and the males keep to the old ways. Only the females bite, and those of the House Gnat are very keen to gorge themselves with the blood of man and mammals, or even of birds. It may be an acquired taste, but it has got a strong hold now; and in the Common Gnat it seems clear that the draught of blood is a useful stimulant before egg-laying. On the other hand, it has been proved experimentally that the blood-sucking is not indispensable. The cause of the irritation produced after the insertion of the sharp needles and the subsequent suction is rather subtle. It was investigated twenty years ago by Professor Schaudinn, who showed that a partner-fungus lives in three little sacs which are connected with the gnat's gullet. They seem to assist in the fermentation of the sugary food, and relatively large quantities of carbonic acid gas are generated. Some of this gas will be introduced into the wound the gnat makes when she bites; it will cause irritation of the muscle, and it will also tend to prevent blood-clotting. Moreover, there is an

injection of a minute quantity of the ferment which the fungus makes, and this will increase the blood pressure and also the irritation. It is probable that some of the fungoid cells will also pass over into man's blood, and it has been shown that the symptoms of a bite can be mimicked by rubbing a scratched piece of skin with a gnat's gullet. We see, then, why a gnat's bite is worse than a pin-prick!

There is considerable variety in the life-history of different kinds of gnats; we confine our attention to that of the commonest species, a fine account of which was given by Réaumur in the early eighteenth century. In ordinary cases the female gnats seek out sheltered winter quarters, such as cellars, about the end of September, and they persist in a lethargic state through the cold months. The males all die after the last autumn mating. The females are in good condition in late autumn, with a notable amount of reserve fat in their bodies. It is rather difficult to account for this fatty store, unless it be the residue of what was accumulated by the aquatic larvæ. This is one of the questions which "Alice Through the Looking Glass" omitted to ask during her long conversation with "a very large gnat, about the size of a chicken." The fatty reserve gradually dwindles throughout the winter, but the re-awakening gnat is vigorous enough. It is usually in May that she liberates about 200 eggs, somewhat like small-bore shot, and glues them into an unsinkable and uncapsizable raft, which floats on the surface of a stagnant pool or a rain-water barrel. In two or three days the larva emerges, breaking off a lid on the broad lower end of the shot-like or cigar-like egg-shell.

The larva, popularly called a "wriggler," is a legless creature, fond of hanging head-downwards from the surface film. The suspension is effected by an air tube on the eighth ring of the posterior body or abdomen. This pierces the surface film and opens by spreading out five valves or flaps, like the rays of a conventional star. When these valves close together the larva slips from the surface film and sinks in the water, it may be to the bottom. But soon it jerks itself up again, helped in its vigorous strokes by ten tufts of stiffish bristles on the tip of the tail. There are also four terminal

platelets, two much larger than the others, which contain air tubes and seem to be more important for capturing oxygen than for locomotion. There are plenty of these wrigglers in pools in early summer, and they are interesting creatures to watch with a good lens or a very low power microscope. One of the most important facts in the world is that if they are to live they must be able to hang on to the surface film. When a little paraffin or petrol is poured on a stagnant pool the larval gnats or mosquitoes can no longer hold on, and they drown. This obviously checks malaria.

The larvæ of the common gnat feed at the surface on minute organisms and organic particles which they waft into their mouth by means of bristly mouth parts. Unlike some other species, they are able to thrive in very foul water. They feed easily and well, they grow quickly, they moult their cuticles; and in two or three weeks, after the fourth moult, they turn into big-headed pupæ. These are very different from the larvæ; thus there are two breathing tubes opening far forward, and no food is taken. They are more active than ordinary pupæ, for if we touch one it jerks itself quickly downwards into the water, helped by two terminal tail-flaps. It rises again passively and buoyantly. Within the pupa-husk the winged gnat is built up, and there is a critical moment when the cuticle splits up the back and the fully formed insect seeks to emerge without getting its wings wet.

The mating takes place in the air, and most people have admired the swarms of dancing and noisy males. The females seem to be attracted by the throng—perhaps by the sound. In the case of the Common Gnat there may be two or three generations in the course of the summer, and in each generation there may be three or four broods. There are some quaint people who are always asking: "What is the use of this or that?" As regards gnats, the answer is easy; *they form an important part of the food of many kinds of birds.* Who will not find the gnat's complete justification in its triumphant re-embodiment? One may almost say that gnats turn into birds!

DADDY-LONG-LEGS

Sometimes, especially at the end of summer, there are so many crane-flies or daddy-long-legs rising on the links that the golfers complain of them flying up in their faces and spoiling their play. Perhaps it is a little disconcerting to have such a sprawling insect in one's face ; its legs cover so large an area that one does not know where it is and where it isn't. It has more "leg" in proportion to "body" than almost any other kind of animal, except the quaint spiderish "harvest-men" that stalk about among the stubble in the autumn evening.

It is a bit of a surprise, if one thinks about things, to see a winged insect wriggling out of the ground, but closer scrutiny shows that the crane-fly is emerging from a gaping pupa-case which is standing vertically just below the surface of the soft earth. What we see is near the end of a long story, to which we shall turn in a moment.

But it is interesting to linger over the picture of the crane-flies creeping out of their pupa-cases on the links, for the picture includes crowds of Blackheaded Gulls which are searching over the golf-course for these dainty morsels. It is pretty to see them quickening their pattering to a very rapid run when they detect an insect showing face. The more crane-flies the birds destroy, the better for the turf next year, for the hungry larvæ or "leather-jackets" do a great deal of harm to the roots of the grasses. Not only do they injure links and pasture, but they destroy the roots of cereals and some other crops. They are so destructive that in some parts of Britain the farmers call them "*the* grub" as if there were not many other kinds.

It is interesting to watch among the Blackheaded Gulls the beginning of a sense of property. For if one gull has hit upon a profitable area, *e.g.*, a teeing-ground, rich in emerging crane-flies, will it let another gull join in ? On the contrary, if an intruder alights, he is at once driven off with bad words, and he always goes.

Every one knows the full-grown flying Daddy-Long-Legs, with the almost inch-long body, the big wings and the

very lank limbs, which seem in fact too long for usefulness. There are two common kinds—*Tipula oleracea* of earlier summer, with a greyish body and an expanse of wing about two inches across, and *Tipula paludosa*, that comes out from July to September, with a reddish-brown body and shorter wings. No one can readily confuse either of them with gnats, which have not such ridiculously long legs, though in truth they are long enough. Like gnats, the daddy-long-legs are two-winged flies, and it is interesting to look carefully at them to see behind the wings a pair of quivering rodlets with pinhead-like ends. These "poisers," as they are called, are restricted to two-winged flies (Diptera) and the males of scale-insects; they are the equivalents of hind-wings, and discharge some obscure sensory function. As "poisers" are true correspondents of hind wings, one would expect among the thousands of different kinds of two-winged flies to find some types with transitional forms between wings and poisers. No such case is known.

If we follow the lanky creatures that wriggle out of the ground and escape the hungry eyes of the gulls and other birds, we see that they scramble on to the grass and take to flight. The females meet the slightly smaller males, and pairing takes place. Thereafter the males die, and so do the females after they have deposited their eggs. When about to lay, the female usually seeks out a damp spot in the ground, or she may deposit the eggs among coarse grasses and rubbish.

When she is laying, she holds her body bolt upright, with the hindmost and longest legs on the ground and the other two pairs in the air; and she has an egg-laying organ or ovipositor at the tip of her tail that helps in the process of literally popping the eggs into a hole or crevice. The eggs are little black ellipses, and one female may lay about three hundred.

It does not seem easy to explain the crane-fly's long legs; they are readily broken off on slight provocation; the insect is very apt to leave them behind; and when they are lost they do not seem to be missed. The only light we have on the subject is that the long legs appear to be serviceable

in struggling among the jungles and thickets of meadows and hedge-row, and in the process of egg-laying.

Out of the egg in about a fortnight there is hatched a larva—a sort of subterranean maggot. In contrast to the adult insect it has no legs, but it moves about in the soil by contracting and expanding its muscular body. Its black head is retractile and inconspicuous until the strong biting jaws are protruded. With them it plays havoc with all sorts of roots. The blunt hind end is marked by six tubercles. On the last ring of the cylindrical body there are two breathing openings, by which air from interstices in the soil passes into the respiratory tubes, which penetrate into every hole and corner of the internal parts. In most animals the blood goes to the air (*e.g.*, on gills or in the interior of lungs) ; but in insects the air goes to the blood.

The larval crane-fly writhing in the soil is a great contrast to the larval gnat or mosquito wriggling in the pond ; but the essential features in the two life-histories are much the same. The larva feeds, grows, and moults—again the necessary sequence ; and at last it is a full-grown "leather-jacket" about an inch long. It is an unattractive creature, with a tough skin (as its popular name suggests), and very difficult to kill, as the farmer well knows. A summer leather-jacket may become an autumn crane-fly ; but an autumn leather-jacket will remain as such in the ground until the following spring. If there be frost, it wriggles beyond the reach of its chilly fingers.

When the time for the great change or metamorphosis draws near, the leather-jacket takes up a vertical position just at the surface of the ground, and becomes a pupa or chrysalis which has spines on each ring of its body and two horns on its head. Inside the pupa-case the miracle occurs ; the development begins afresh ; the old house is broken down and a new one is constructed on a different architectural plan—that of the winged insect. The pupa wriggles upwards out of the chrysalis case, helped by its spines, and then, half out of the earth, there is a splitting of the cuticle and a liberation of the winged Daddy-Long-Legs.

If no creature's' hand were against Daddy-Long-Legs it would fare badly with the farmer. He may clear away the rank grasses which the crane-flies love ; he may clean the hedgerows which give them shelter ; he may harrow and roll ; he may drain the moist places where the female insect finds opportunity to pop its eggs into the soil ; he may use gas-lime and " tipulin " ; but he has still to confess that Daddy-Long-Legs is too much for him. Luckily, however, there are natural enemies which tend to keep the balance even. For the larvæ are picked out by rooks, starlings, lapwings, and gulls, or crunched up by moles. The winged crane-flies are caught by rooks, Blackheaded Gulls, and swallows, and the wasps that people grumble at so much must get credit for playing a useful part.

THE GREEN-FLY

If the Plant-Bugs (of the order Rhynchota), which suck sap, got the upper hand the whole world of life would probably come to an end in a few years. Among these plant-sucker sthere is the family of "green-flies," "plant-lice," or Aphides, which do a great deal of damage.' One sees them covering the stems and leaves of rose-bushes and pear-trees, beans and hops—a crowd of wingless insects which in the summer months are all females and multiply very quickly by virgin birth.

There are many interesting facts about honey-dew, but we are most concerned just now with the loss it means to the plants and the gain to the insects. In the mouth of the Aphis there is a proboscis, and inside this there are four piercing needles. This instrument is thrust into the stem or leaf, and it sometimes goes far in, reaching the tissues containing sugar and other reserves. In some cases a fluid is exuded from the salivary glands of the Aphis, and this hardens round the proboscis, forming an extra canal, within which the piercing and sucking instrument can work with great facility. How well fed the insects are may be gathered from the rate at which they multiply, for one cannot forget Huxley's calculation that if the progeny of one mother Aphis

all survived and multiplied there would be at the end of summer a mass of green-flies big enough to weigh down the population of China. This does not happen, for the multiplicatlon is checked by the limited supply, and also by the bad weather, and also by the appetite of the little beetles called Lady-Birds, the beautiful Lace-Wing Flies, and such birds as Titmice, which are all very fond of green-flies. Also of fascinating interest is the partnership that some kinds of ants have established with Aphides, which they utilise as their "cows." There is no doubt that they milk and tend the Aphides, that they carry the winter-eggs into shelter and look after them, and that they take the young ones in early summer to their leafy pastures.

On fine days in early autumn the air is often crowded with minute green-flies of various kinds. We see them rising and falling like the droplets of a feeble fountain. They do not fly far with their lightly built transparent wings; sometimes they look as if they were almost floating. Anyhow, their numbers are prodigious, and in some suburbs of the town they darken the air and cover our clothes like snow-flakes in winter. Some of those we have collected lately are blackish, but they also are "green-fly" in the technical sense, with various aliases, such as plant-lice, blight, or aphides. What is their story?

The typical life-history of green-fly is this: Eggs which are laid in crevices in autumn remain dormant throughout the winter, but hatch in the spring, giving rise to wingless females. These multiply parthenogenetically, as was discovered by the old French naturalist Bonnet; in other words, they produce eggs which develop without requiring to be fertilised. These parthenogenetic eggs develop inside the mother into small wingless females, so we require another awkward technical term to describe the situation—the term viviparous. Throughout the summer, there is generation after generation of wingless, parthenogenetic viviparous females which infest our rose bushes, pear trees bean plants, hops, and so on.

As a young one is ready in a short time, often a week or

so, to be itself a mother, the generations succeed one another very rapidly.

In typical cases there are no males throughout the summer months, and experiment has shown that the virgin-birth may be continued for four years in the artificial summer of a greenhouse. But although males are not usually born in the summer, there is often an interruption of the wingless generations by the appearance of winged forms which secure migration from one plant to another. The flights of winged ants that are sometimes seen are nuptial flights, in which the males and females meet; but it is different with aphides. The cloud of winged atomies seems often to consist of females only, and although males appear in autumn and are often winged and may share in the migration, it should be carefully noted that the females that are fertilised by the males in the fall of the year, and lay the eggs hatching next spring, are always wingless, and that their mates are often in the same condition.

It is not very easy to tell the story quite clearly, because it is subject to considerable variation, but the outline we have given is often true—fertilised eggs hatching in spring, viviparous parthenogenetic wingless females in many successive generations through the summer, migrating winged females also viviparous and parthenogenetic, males (winged and wingless) which fertilise the wingless females who lay the eggs we started with. The migration is often followed by the production of males and pairing females.

Green-flies are greedy insects which, if unchecked, would soon make an end of all vegetation, as one of them—the Phylloxera—often threatens to do in European vineyards. They make an abominable mess of many of the plants we are fond of, smothering them with their progeny and honey dew, which has already been spoken of. Apart from their transparent wings they have no great beauty, and we like them best when they are reincarnated in other insects. They are undoubtedly our enemies, but we cannot deny that they have their points. It is an extraordinary everyday miracle, this rapid transformation of vegetable sap into green-fly, this torrent of life, this flourishing maleless multi-

plication, this see-saw of asexual and sexual multiplication of viviparity and oviparity, this persistence in spite of the severest sifting. A little one soon becomes a thousand, and a small band a great army.

We have given only a glimpse of the biological and human interest of these little creatures which we have just been watching as they danced in the air among the trees in the garden. Ours were not the only eyes that were on them, for we saw some sifting going on, and this led us once more to admire the balance of the System of Animate Nature. If it were not for this balance it would be so easy for green-flies to put an end to everything!

STORY OF THE YOUNG ANT-LION

The ant-lion is a common insect that verges on the incredible. It is not a native of Britain, but several kinds or species are abundant in various parts of Europe. It is common around Paris, for instance, where Réaumur studied its extraordinary habits in the early years of the eighteenth century. The full-grown insect, which is somewhat like a delicate dragonfly, is not well known, for it comes out at night; it is the larva that has been the subject of many studies, the last and best being by Professor Doflein, of Freiburg.

Ant-lions, by which we mean the larvæ, frequent dry, well-sunned waste-places, with loose soil, in the vicinity of a wood or copse where there are lots of ants. When full grown they are about half an inch long, with a somewhat shield-shaped, arched posterior body, bearing a mobile head with formidable sharp-pointed jaws, a little like pruning hooks. The general colour is pale yellow, often obscured by adhering particles of sand, but the numerous bristles on various parts of the body are dark brown or black, there is a broad reddish band across the back, and there are pigment spots every here and there.

When the ant-lion emerges from the egg it is a tiny miniature of what it afterwards becomes. But it is to the manner born as regards ants. A little creature, only

a twelfth of an inch long, yet it proceeds to make a funnel-shaped pit in the ground, ensconces itself at the foot with only the jaws showing, and waits for an ant bigger than itself to tumble into the trap! In suitable places, such as a sandpit, there may be scores of funnels of different sizes, up to four inches in diameter; and when a funnel works well the ant-lion keeps to it for months. The requirements are that the soil is not damp or over-hard, that the place is sunny yet sheltered from the wind, and that there are many ants and other small insects in the vicinity.

But numerous experiments make it clear that we must not think of the ant-lions *choosing* a suitable locality in our sense of the word choosing. They move about in spiral courses, hind-end always in front, towards warmth, towards light, away from dampness, and sooner or later they find a satisfactory spot. Like some other animals, they are always automatically adjusting their bodies (as if they had a gyroscope inside) so that they are equally stimulated to right and to left. In darkness and in uniform diffuse daylight they tend to remain quite still, but when there is inequality of stimulation they simply have to move on. Of course, it is sometimes necessary to make a sort of compromise, for inequalities of light and inequalities of warmth may pull in different directions, in experimental conditions at least. Professor Doflein notes the interesting fact that during many years devoted to studying ant-lions in his laboratory and study he never lost one, for even if one escaped he could always predict where it would be found. The ant-lion's consistency in moving backwards is remarkable; the creature would always do itself credit before royalty. On no occasion will it make an exception and move head-foremost. The meaning of its always moving backwards is probably to be found in the fact that it is a great burrower, and it always burrows tail foremost.

Having found a suitable place, the larva moves backwards in a circle, ploughing into the earth with its posterior body, which ends in a cone. Particles of earth from the inner side of the circle are shunted on to the top of the burrower's head, and are sent flying outwards with an explosive jerk.

There is a most admirable anterior joint that makes this easy, and the arrangement of the bristles on the body, almost all directed forwards, also helps in the performance. The legs assist a little in the burrowing, but most of the work is done by the hind-end of the body.

The ant-lion continues ploughing round in circles and hurling out the earth until the funnel is deep enough. It then buries itself at the foot with only the jaws protruding, and it always keeps its face away from the light. If an ant tumbles into the pitfall, the jaws lose no time in clinching, and perhaps there is some poisonous juice. Along the under side of each jaw or mandible there is a groove within which another of the mouth parts plays backwards and forwards, helping to draw in the juice of the impaled ant. The groove leads into the mouth-cavity, for the mouth aperture is practically suppressed. The beginning of the food canal is very muscular, and functions as a suction-pump; and when the victim has been sucked dry its body is tossed out of the trap. One of the many peculiarities connected with the feeding habits of the larval ant-lion is that the stomach ends blindly. Any undigested material must come out at the mouth!

The tossing movement that is seen in making the pitfall and in throwing out the sucked victim occurs also in a third connection. When an ant has slipped a little way down the slope and tries to recover its foothold the ant-lion does an extraordinary thing. It bombards the ant with sand, and the almost inevitable result is that the struggling insect is borne to the foot of the funnel and then seized as usual. This bombardment seems at first sight almost devilishly deliberate, but Professor Doflein's interpretation is different and almost certainly correct. When the bombardment is carefully watched it is seen to be towards all sides of the funnel. There is no aiming at the struggling ant; it is merely a repetition of the usual tossing action that has its trigger pulled when moving grains of sand touch the exquisitely sensitive bristles on the burrower's body. The fact of the matter seems to be that the ant-lion is an insect of low intelligence, but well endowed with a repertory of

ready-made tricks. It has a poor brain, but it has several very perfect inborn capacities, which work well from the very first. These actions correspond to the capacities we illustrate when we swallow, or cough, or sneeze, or draw back our finger from a hot surface. They are technically called "reflex actions." To throw off sand from the top of its head is to the ant-lion "as easy as winking"; it needs no learning. The creature is a little automaton that does a few things extraordinary well. But although the ant-lion does not nowadays need to use its mind to catch the ants, it does not follow that the mind was not used during the long ages when the inborn dexterities were being established.

DRAGON-FLIES

As long ago as 1883 the French entomologist Amans suggested that hints for electrical flying-machines might be got from dragon-flies, and one of the first successful French types of monoplane was called the "Demoiselle," which is also the name of the dragon-fly. One cannot, indeed, watch the larger dragon-flies "skimming" over the water without thinking of aeroplanes, and Mr. R. J. Tillyard, who has written a fine *Biology of Dragon-flies* (Cambridge, 1917), says that "a study of the different effects on flight of angulated and rounded hind-wings, as well as of the arrangements of braces and cross-pieces suggested by various parts of the dragon-fly's wing, might well lead to further improvements in our models, and might even suggest a solution for 'hovering' on simpler lines than anything yet attained." Actually, since 1917 many improvements have been made. It is understood, of course, that the wings of dragon-flies strike the air, and that with almost incredible rapidity of vibration, while "planes" do not.

As we see dragon-flies hawking over the pond, darting up and down the stream, sailing over the moor round the "lochans" where they were born, we recall Tennyson's phrase, "a living flash of light." The gauze-like, never folded wings, the conspicuous eyes, the metallic sheen of the armature (Tennyson's "bright plates of sapphire mail"),

the long, narrow posterior body, the baffling rapidity and sure poise of the flight, and the mysterious way in which many of them disappear and reappear as they fly around us, combine to make them unusually attractive insects, though one of their many popular names, "Devil's Darning-needles," is scarcely enthusiastic. In spite of another name, "Horse-stingers," they do not sting, and they are almost altogether beneficial as far as man is concerned, for they wage effective war against flies and gnats and other troublesome insects. Mr. Tillyard caught one with its mouth so full of mosquitoes that it could not be shut. "There must have been over a hundred, all tightly packed into a black mass." It is suggested that the mosquito pest in the ornamental waters of parks might be checked by introducing suitable dragon-flies, whose larvæ as well as adults would prey upon the nuisance. A "glorious red" species has become well established in the Botanical Gardens at Brisbane, "and certainly adds a vivid touch of colour to its lovely surroundings."

The flight of dragon-flies must be near perfection; it is sometimes a sequence of lightning-like jerks, sometimes a regular swift sculling close to the water, sometimes a zigzag spiral ascent in the air, sometimes an even easy skimming "through crofts and pastures wet with dew." There is a remarkable peculiarity in the direct way the numerous muscles of flight are connected with the wing-bases; the velocity may rise to nearly sixty miles an hour; the two pairs of wings work quite independently, yet harmoniously. For some distance, like a wasp, a dragon-fly can fly tail foremost. They do not usually wander far from their favourite haunts, but some species with a migratory bent may travel hundreds of miles. An Australian form, *Hemicordulia tau*, has recently colonised Tasmania, across a strait two hundred miles wide. The perfection of flight is connected with the habit of catching insects on the wing, and with this also we associate the very mobile head and the high development of the eyes, both reminding us of birds. The sense of smell seems to be practically absent; the sense of hearing is probably represented by a sense of poise; taste and touch

are as in many other insects, but vision is probably the keenest among backboneless animals. The number of facets and lenses and other eye-elements in each compound eye varies from 10,000 to 28,000; and the range of vision, as far as the detection of movements is concerned, is up to 10–20 yards, the limit for other insects being about six feet. "When a dragon-fly is caught and held in the hand the eyes are seen to glow with a most beautiful light, generally of a semi-metallic green or blue colour, sometimes red, brown or grey. This is a reflection of light from the interior of the eye, and is called the *internal light*."

Dragon-flies have fine brains, and they are as clever as is good for them. When a large one has been accidentally decapitated the rest of the body may for a couple of days flutter its wings and even climb up curtains with its legs. This points to remarkable independence in the nerve-centres (or ganglia) of the ventral nerve-cord, and does not bear on the question of intelligence, any more than does the fact that if the terminal rings of a large dragon-fly be snipped off and presented to the head, they will be devoured "with apparent relish." We are misunderstanding the dragon-fly badly if we imagine that it ever "knows what it is eating"!

As regards body-colouring, dragon-flies deserve a first place among insects, though they are excelled by butterflies if the wings are taken into account. Various coloured materials or pigments are deposited in the cuticle and skin in the form of granules, and there is sometimes an exudation of pigment on the surface, like the bloom on ripe fruit, when the insect is becoming mature. "Interference coloration," such as we see on a soap-bubble, is very common, and when it is combined with "pigmentary coloration" the result is often extraordinarily brilliant. Green, blue, violet, purple, red, orange, yellow, and other colours are displayed in exuberance, suggesting that their possessors do not need to be afraid of self-advertisement. In some larvæ there is evidence of a slow power of colour-change, in harmony with the hue of the surroundings.

It is doubtless because of their beauty and graceful movements that what we call dragon-flies are elsewhere called

"demoiselles," "Wasserjungfer," or the like (so much depends on the point of view); but it is interesting to note that except in the sub-family Æschinæ the females are seldom seen flying upon the water except when pairing or laying the eggs. The males are the conspicuous demoiselles; the females seek cover among grass and herbage. There is often a sort of courtship, in which the males dance in the air before their desired mates and show off some of their good points. The male of one species waves a pair of white ribbons to attract the female's attention. There is occasionally a miniature *pas de deux* (a dance for two persons) before pairing.

The eggs may be laid in little holes cut in the stems of iris, reeds, or even osiers, or among the roots of mosses growing on damp rocks, or in firm, gelatinous ropes entangled on submerged twigs; but in most cases the female skims over the quiet or flowing water, and touching the surface now and then with the posterior tip of her body liberates masses of eggs, surrounded with jelly. The gelatinous substance dissolves in the water and the eggs are scattered about on the bed of the river or on the floor of the pond. Out of the egg-shell there emerges a "pro-nymph" which grows very rapidly for a few seconds or minutes, and then, moulting its cuticle, becomes a wriggling free-swimming larva fully equipped for the bread-and-butter part of the business of life. The larvæ live under water for about a year, or, it may be, for as many as five years. They are extraordinarily voracious, eating almost any kind of small living animal from Protozoa upwards, and even attacking tadpoles. Mr. Tillyard starved one for a week and then gave it mosquito larvæ, sixty of which it swallowed within ten minutes. "After that," we read, "nothing would tempt it." The larvæ are given to cannibalism within their own order, and are sometimes seen stalking their own near kin.

The most remarkable larval characteristic is the protrusible food-catching "mask," so-called because it hides the other mouth-parts or even the whole face. It consists of the third pair of mouth-parts (labium) fixed on the end of a jointed hollow stalk. When the victim is within reach the mask is

shot out with great rapidity, two sharp hooks fix themselves automatically in the booty, and after the struggles become less violent the mask is drawn back to its position of rest beside the mouth, where the first pair of mouth-parts (the mandibles) begin the work of chewing.

The respiration of the aquatic larvæ is also very interesting. Water passes into and out of the terminal part of the food-canal, which is often furnished with a beautiful "branchial basket." When the water is driven out forcibly the larva is jerked forwards, so that the functions of breathing and locomotion work together. Many of the larvæ have also got thread-like or plate-like tracheal gills, as in Mayflies. The air captured from the water is carried to every hole and corner of the body by means of branching tracheæ or air-tubes, which are characteristic of all insects, but the stigmata or openings of these tubes, which are wide open in the adult dragon-fly, are either closed or of very slight importance in the larva. Had the tracheæ wide openings as in the adults, the larvæ would drown.

During the long larval life many changes occur: the facets of the compound eyes increase in number, the simple eyes make their appearance, the feelers get more joints, the beginnings of the wings are formed, and the thorax changes as they develop, and at intervals—from eleven to fifteen times—there is a thoroughgoing moult or cuticle-casting. This means not only shedding the covering of the body (Tennyson said: "An inner impulse rent the veil of his old husk"), but a surrender of the lining of the air-tubes and of the foremost and hindmost parts of the food-canal.

After prolonged internal changes towards the architecture of the adult, the great change or metamorphosis occurs. The larva becomes listless and loses its appetite, it changes its colour and appears tense and swollen—it is manifestly out of sorts. It climbs or crawls out of the water and fixes itself firmly to a reed or some other support. It arches its back and its cuticle splits along the mid-dorsal line, it gets its head and thorax free, it draws its legs and wings out of their sheaths, it hangs head downwards and its limbs harden, it waves about and succeeds in jerking itself upwards again, it

holds fast to its support and withdraws the tail from the larval husk; it drives blood into the crumpled bag-like wings and expands them. The presence of blood in the wings produces a peculiarly beautiful iridescence, which lasts for hours or days till the wings dry. The favourite time for the remarkable metamorphosis, which Réaumur described with great perfection about 1740, is at or near dawn.

Dragon-flies must have had a long pedigree, for in the Upper Carboniferous epoch they had many fine representatives, including the truly magnificent *Meganeura monyi*, which had a spread of wing of about twenty-seven inches, far exceeding that of any living insect. Since these ancient days, which were not, of course, near the beginning of dragon-fly history, the order has occupied a singularly isolated position, having no near relatives. Thanks to their powerful baffling flight, their keen, long-sighted vision, their carnivorous habits, their inconspicuousness when resting, and other qualities, dragon-flies have a strong grip of life, and long may it last.

They are represented all over the world by more than 400 genera, with about 2500 species—a testimony to success! But they have their enemies. Kingfishers are expert in catching them; spiders snare them; lizards and snakes snap them up; the giant sundew of Australia takes heavy toll. The aquatic larvæ are devoured by their own relatives, by the young of the water-beetle Dytiscus, and by trout.

Very striking is the habit of *Polynema natans*, one of our "fairy-flies" (tiny Hymenoptera), which uses its wings for swimming under water and lays its eggs inside the eggs of a dragon-fly deposited in the leaves of water-lilies. The grub of the fairy-fly hatches out in the dragon-fly's egg and devours it in a few days. Mr. Tillyard, to whose fine book on *The Biology of Dragon-flies* we are greatly indebted, notes that the most deadly enemy of full-grown dragon-flies is the trout; and here man has his thread in the web of life. In Tasmania the introduction of the English trout has reduced the dragon-fly fauna to a minimum. A two-pound trout, caught by Mr. Tillyard on the Macquarie River, in

Tasmania, had in its stomach the undigested heads of thirty-five dragon-flies. But this means that injurious pests like scale-insects will increase.

MAYFLIES

On the stones or among the weed in the river, one often sees, in the summer-time, a number of wriggling flattish creatures, with three pairs of legs, with two or three filaments at the tail end, and with a double row of delicate platelets—the breathing organs or tracheal gills—on the posterior part of the elongated body. Some of these wriggling creatures are young Mayflies, though there is not much about them that suggests the delicate adult insects which rise in living clouds from the quiet reaches of the stream in the end of May or in the beginning of June. Day-flies or Ephemerides they are called because of the shortness of the winged chapter in their life-history. It may not last more than a day. Indeed, there is one case known where the aerial life lasts only for an hour! Yet we are apt to misunderstand the Mayfly story unless we get firm hold of the fact that it is only the winged part of the life that is so very short. Many of them have an aquatic life of two or three years, so they are not such short-lived creatures after all.

There is a useful Natural History idea here, that different kinds of animals lengthen out or shorten down different stages in their life-cycle. Some animals have a very short youth, a long period of full-grown strength, and a rapid end; others have a short period of intense vigour and a long-drawn-out decline, as happens sometimes among mankind. What do the Mayflies show? They have a very prolonged juvenile life beneath the water, a greatly reduced period of maturity as winged insects in the air, and then an abrupt death.

The larvæ or nymphs of the Mayflies are suited in many interesting ways to the conditions of their life. They absorb the oxygen in the water by means of the delicate "tracheal gills" on the back of some or all of the first seven segments of the so-called "abdomen." The long

tail-filaments may also help in this breathing, for what always happens is that oxygen seeps into the internal air-tubes or tracheæ which penetrate into every hole and corner of the body. The tracheal gills are sometimes neatly protected by a cover and by interlacing fringes of bristles from the risk of being clogged with fine silt. Some of the nymphs that move quickly show the "stream-line" form of body that is seen in many aquatic animals, such as fishes. In the young Mayflies it is adapted to reduce resistance when they are swimming, and also to lessen the grip of the current when they are holding on. In many cases there are grappling hooks on the limbs which clutch the surface of stones, and there is a correspondence between the flattening of the body and the rate of the stream's flow. That is to say, when the current is very rapid the only kinds of Mayfly that can live in it are those with a much flattened body. In a kind called Rithrogenia, which lives in torrential streams, attempting the next-to-impossible, as animals so often do, the tracheal gills are flattened and extended laterally, so that they rest against the stone, and form a large oval attachment-disc of singularly limpet-like form. As a great naturalist used to say: Wherever we tap Organic Nature, it seems to flow with purpose. In other words, all living creatures are bundles of fitnesses, though the adaptations are more striking in some cases than in others. We could not find a better illustration than the limpet-like grip of this particular Mayfly nymph that lives in the rush of mountain torrents. How different, on the other hand, is the habit of a common American Mayfly, called Hexagenia, that burrows in the bed of the river or lake. The forelegs are flattened into scooping shovels, the jaws form relatively enormous projecting tusks! By using these two body-tools alternately, this young Mayfly tunnels its way along—a sort of sub-aquatic mole!

Many of the aquatic larvæ of insects depend for their food on very minute living creatures that drift or swim in the water. They differ in interesting ways in their methods of capture. Thus the aquatic larvæ of some flies have rapidly vibrating fans that make a whirlpool around the

mouth, sucking in microscopic food. Or again, some of the caddis-worms make delicate and beautiful seine-nets of silk, which strain minute organisms out of the currents passing through. The larval stage of the " Howdy " Mayfly which is almost as quick as a minnow, holds firmly to a stone with its middle- and hind-feet, and " extends its fore-feet with their paired fringes of long hair outspread like a basket to receive what booty the current may bring." Many larval Mayflies, however, browse in a more commonplace way on the microscopic vegetation that adheres to the surface of the stones they frequent. Others climb up the stems of water-plants, browsing as they climb. On the whole, they are vegetarians or devourers of the fine organic dust that is floated away from decaying plants and animals.

After the relatively long period of aquatic life, lasting for weeks or months or years, and punctuated by successive moultings (a tax, as we have said, on growth), the young Mayflies undergo a remarkable change of structure—the metamorphosis. The end of this is that the nymphs float on the surface of the water, wriggle themselves very rapidly out of their split husk, emerge as winged insects and fly away. Sir John Lubbock spoke of the suddenness of the transformation : " From the moment when the skin first cracks not ten seconds are over before the insect has flown away." If we are fortunate enough to catch on our sleeve a Mayfly that has just left its nymph-husk floating on the surface of the water, and taken its first flight, we may observe that it seems impatient to get rid of yet another envelope which enswathes its body. The casting of this thin greyish cuticle is the beginning of adult life. In small Mayflies, the resting associated with ,this final moult (the " subimaginal quiescence " the entomologists speak of) may last for only a few minutes ; in larger forms it lasts for a day or two. But whether it takes minutes or days, the outcome is the same—the unveiling of a graceful winged insect with smooth and shining surfaces and beautiful coloration. It rests on our sleeve quivering after its efforts—a large-eyed, fragile creature with its fore-legs stretched out in front, with fan-like fore-wings held up

vertically and the hind ones inconspicuous, with two or three long tail-filaments, with minute antennæ and with mouth-parts reduced to remnants. For the time of eating is over; the dance of love is about to begin.

Large numbers of Mayflies often leave the water about the same time and rest on the bushes and herbage, undergoing their final moult. "They often bend the streamside willows with their weight." In the evening, having cast their "ghost," as some of the old naturalists called the last-moulted husk, they rise in countless numbers like a living mist. There are few more impressive sights in the realm of living creatures. In their fine book, *The Life of Inland Waters* (Ithaca, 1916), Professors Needham and Lloyd tell us that "the adult males fly in companies, each species manœuvring according to its habit, and the females come to meet them in the air." The days of hunger are over, it is the hour of love. In his fine monograph on Ephemerids, the Rev. A. E. Eaton describes the behaviour of some of the more conspicuous Mayflies, especially the males. An intermittent action of the wings results in "a dance-like motion almost vertically up and down—a fluttering swift ascent, and then a passive leisurely fall, many times repeated." The cloud of wings rising and falling over a quiet stretch of the river is a very beautiful sight. There is chasing, embracing, and separating; the pairing is usually during flight. The smooth surface of the water is dimpled when some of the dancers touch it, and it is there that the eggs are shed, in a somewhat random way, it seems. As the evening passes, the Ephemerids may pass also; for the continuance of their race is fatal to the individual life. There is one kind at least in which the aerial life is over in an hour, and in many it is over by nightfall. But there are other kinds that may survive for several evenings if they get suitable rest during the day. In any case, there is no getting past the fact that the dance of love ends in death. But the eggs are laid in the stream and sink down there, so that the future of the race of Mayflies is safe.

We must not think of the story of the Mayflies as if it had a peculiar plot of its own, for, as we have said, there is

often a sharp contrast between the youthful feeding stage and the full-grown multiplying stage. We see that in the contrast between caterpillars and butterflies. What is so striking in Mayflies is that the youthful aquatic period of feeding and growing may last for years, whereas the adult aerial period of pairing and reproducing may be condensed into a few hours. There is an extraordinary vividness here in the rapidity with which death comes as the price to be paid for giving origin to new lives. How true was the saying of the poet Goethe: "Nature holds a couple of draughts from the cup of love to be fair payment for the pains of a lifetime."

Before we leave the Mayflies, let us inquire into the part they play in the economy of Nature. In their juvenile life they are "middle-men" between the micro-vegetation on which they mainly depend, and the numerous carnivorous water-animals, like trout, which feed largely on young Mayflies. They are particularly important as a staple food for freshwater fishes because many of them are well represented by nymphs of good size all round the year. Professors Needham and Lloyd, to whom we are much indebted for their fine account of Mayflies, select as a particular case a kind called Callibætis. "It is an active nymph that swims from place to place by means of quick strokes of its tail and gills, and that clambers freely about over shore vegetation. It is an artful dodger; and it is protectively coloured. It feeds on a great variety of vegetable substances living and dead, and hence finds abundant food in every weedy pond. It is eaten by every carnivore in the pond that can catch it; and, doubtless, it has many enemies that exceed it in swiftness and many others that lie in ambush and capture it by stealth. Hence though nearly always present, it rarely appears abundantly in old ponds." But the practically important fact is that this much appreciated Mayfly has great possibilities of multiplication if it had not so many enemies. Its life-cycle occupies only six weeks, and each female may lay 1000 eggs. In six weeks these will have developed into 1000 winged insects—say 500 males and 500 females. But each of these females

might produce 1000 eggs developing into a total of half a million grand-offspring of the original pair. There would be, theoretically, 125,000,000,000 great-great-grand-offspring. Of course, this does not happen, because of the multitude of enemies. But the suggestion arises that if we could shelter the young Mayflies in some artificial pond where there was plenty of food, but an absence of enemies, then it might be possible to rear enormous quantities of young Mayflies that could be emptied into waters where useful fishes abound. And if we scatter Mayflies in the water, we shall assuredly find them in many days in the form of trout!

MANTIS

Perhaps the mantises are the most whimsical of all insects. It is not merely their attitude of apparent devotion that is striking, but they are strange in their tendency to form leaf-like expansions on their sides and limbs, in the formidable toothed shears with which they seize their booty, in their stealthy movements, in their wasteful voracity, and in the confusion of the amiable and the edible in the female's mind. A fine description of them has been given by Fabre, but we must not repeat his gruesome tales; it is enough to say that there is cannibalism among the mantises, and the female of the well-known European species, *Mantis religiosa*, does not hesitate to devour her own mate.

Yet they look all innocence, standing so quietly in a half-upright position, with bowed heads and folded arms. It is the large size of these front legs that brings about the semi-erect pose and the unconsciously hypocritical supplicating. "Soothsayers" they are sometimes called, and there are pretty stores about their kindness in pointing out the way a wandered child should take! But all the time the mantis is after the main chance, and when it has focused its insect-victim, the long limb sweeps out, and one toothed part shuts upon another toothed part. The contrivance reminds one a little of an instrument sometimes used in pruning the high branches of trees: a hinged, sharp blade at the end of a long pole is "pulled to" with a rope, and snaps the

branch off. The mantis holds its toothed leg to its mouth, bites off a piece of the victim with its jaws or mandibles, then moves it away again, and looks at it before the next bite. The creature reminds one of a schoolboy eating an apple and between bites scrutinising its diminishing bulk.

But often the mantis throws away its booty half eaten, and catches another. Like carnivores of higher degree—stoats, for instance—it is very wasteful, destroying more than it eats, and we suppose that the explanation is the same in both cases: the presence of a victim pulls the trigger of an irresistible killing instinct. Perhaps we should have said that mantises belong to the cockroach-cricket order of Orthoptera, and that they have specialised as carnivores. They are related to the leaf insects and walking-stick insects, which are strictly vegetarian.

Most mantises move slowly, and are unsuited for flight. Probably, therefore, it is of survival value to them that they should be like their surroundings, as is very strikingly seen in some of those that live habitually among leaves, or lichens, or even flowers. The cloak of invisibility is equally effective in those that frequent the brown desert. In the common Praying Mantis there are two varieties, green and brown, and the Italian naturalist, Cesnola, proved the protectiveness of the coloration by precise experiment. With silk thread he tethered twenty green mantises among green herbage and a similar number of brown ones among withered grass. After seventeen days his tethered prisoners were all alive and well, having escaped the notice of their enemies. Cesnola then tethered twenty-five of the green variety among brown herbage; all were dead after eleven days. In the converse experiment, of forty-five brown mantises exposed on green grass, only ten survived at the end of seventeen days. Most of the mantises that perished were killed by birds; a few of the green ones were eaten by ants. This experiment is very conclusive, and it is plain that in a parched land the brown variety would prevail, while amidst luxuriant verdure the advantage would be with those wearing the green.

The Praying, or rather *preying*, Mantis does not occur as a

native insect in Britain, but it is easily kept alive in well-sunned surroundings. It is common in Europe as far north as Havre. It seems to be a Mediterranean species, of Tertiary origin, that has spread northwards, working its way up such valleys as the Rhone. It is well represented in the Valais, *e.g.*, near Martigny, and in Provence. Its predilection is for dry atmosphere and abundant sunshine. It is a successful animal, occurring not only in France and Switzerland, but in Germany, Austria, Italy, Russia, North Africa, and as far east as China.

A large South American mantis has been known to secure a small bird. It was beginning to eat it when the observant entomologist intervened and secured both. The European mantis keeps to insects. When it is young it feeds on small creatures like green-flies; by and by it aims at larger booty, such as blue-bottles and butterflies. It is said to be consistent in refusing to have anything to do with caterpillars. Even from the first there is cannibalism.

The life-history of the Praying Mantis includes three chapters. First, there is the embryonic period inside the egg, hidden in the egg basket, which is fastened to a twig or a stone. In Switzerland, for instance, this chapter lasts from autumn (September to November) till May. If the egg basket is transferred to a warm room the hatching may take place as early as February. The second chapter is the larval period, which lasts from the hatching till August. The larvæ wriggle out from the compartments of the egg-basket by means of spines on the temporary sheath that covers their bodies. Let us think of a sack-race, with the sack over the head as well. They contract and lengthen; they press against the framework of the egg-basket; the spinosities all point backward; they win their way through. In some tropical mantises the emergent larvæ hang themselves upside down in the air by means of two threads issuing from two minute appendages (cerci) at the posterior end of the body.

There they hang, for hours or days, till their first moult is accomplished. The third chapter is that of adult life, which lasts in the European "soothsayer" from the middle

of August, the time of the final larval moult, to late autumn. The male mantis lives for a month, the female from three to four months.

The egg-basket (or ootheca) is a remarkable structure, well suited for the protection of the eggs and embryos throughout the winter. The specimen we have in our museum is about an inch and a half long, greyish-yellow in colour, convex on its free surface, with a groove on the other for attachment to the twig. The female insects form this as a foam-like secretion, consisting of a substance allied to silk, which dries into a firm resistant fabric. Fabre describes the complicated fashioning of the egg-basket by the mother-insect, and Bugnion has recently added some finishing touches to the story. The important facts are the formation of internal compartments, one for each egg, and the enclosure of these in a thick zone like consolidated whipped egg.

Professor Bugnion found that it took a mantis larva that had become restless about twenty minutes to make its way out of its cradle. It was still wrapped up in a sheath, with backward pointing roughnesses useful in the wriggling, but this ruptured in the twinkling of an eye when the little creature got its head out and its body half free on the surface of the egg-basket. At the head end of this envelope or sheath there is a yellowish and resistant conical cap, which is very useful in resisting friction on the way out. Two threads that come from the posterior end of the body bind the sheath to the wall of the original compartment, and may be nearly half an inch long. When the surface is reached the threads assist in the liberation of the newly born larva from its sheath. In *Mantis religiosa* there does not seem to be any suspension in the air, as in some other mantises, for the young "soothsayers" proceed at once to creep about on the surface of the egg-basket. But there is a sufficient abundance of fitnesses without the spider-like rope trick. What an imagination Nature has!

OLD-FASHIONED INSECTS

We take the familiar cockroaches as types of shy creatures that live in holes and corners—sometimes in shelter under

man's shield, sometimes under natural cover. They live what is termed a "cryptozoic" life, effacing themselves rapidly when disturbed. "Black-beetles" some of them are persistently called, but they are not so black as they are painted, and they are certainly not beetles. They are Orthoptera, along with locusts, crickets, stick-insects, and leaf-insects, far removed from Coleoptera.

The common or Oriental Cockroach, *Blatta orientalis*, is really dark brown, and it is worth noticing that Linnæus, who named it, said "ferrugineo-fusca," *i.e.*, rusty-brown. It is an alien to Britain, believed to have been introduced through commerce during the sixteenth century—whence, we do not know, though the discovery of some specimens living under stones and dead leaves in the Crimean peninsula, points to Southern Russia as its original home. It is now found over the whole earth, and the only thing we are quite sure about is that it must have come to countries like Britain from some warmer clime. For it cannot survive in the more northerly countries except as a sheltered member of the house-fauna. The Common Cockroach has a cousin, the German Cockroach, *Blattella germanica*, dark-ochre or tawny, another naturalised alien, which is wild in the more central and northern parts of Europe and Asia. The politically-minded may be interested to learn that this voracious, destructive, comfort-loving creature is called "the Prussian" in Russia and "the Russian" in Prussia—which is in its way a little parable.

Having these two kinds of "black-beetles," we in Britain have more than enough; but there are unfortunately others—the large American Cockroach, *Periplaneta americana*, common in shipping ports, and the Australian Cockroach, *Periplaneta australasiæ*, a very destructive immigrant which probably came from South-East Asia or Tropical Africa. The international compliments implied in the specific names, such as *australasiæ*, are not always justified. The scientific interest is this, that certain cockroaches, living a penurious life in the open in various countries, get linked to a trade-route, and spread over the earth, as tenants of warm and sheltered places. We have

here a notable instance of the influence of the hand of man upon the animal life of the earth. But there is something rather depressing in the fact that while the total number of different kinds of animals in Britain has not decreased since the repopulation after the Ice Ages, we have received rabbit and rat and lost reindeer and beaver, we have received cockroaches and the bed-bug and lost the wolf and the stately Irish "elk." We have lost not in quantity, but in quality of life.

In his treatise on British Orthoptera, Mr. Lucas notes that for any insect to have two colloquial names indicates that it is common and familiar, and as we spoke of "Black-beetles" as a misnomer we wish to say a word about "Cockroach." It is said to be a corruption of the Spanish "cucaracha," probably meaning some sort of bug ("cuco"); and if this is so, we must agree with Mr. Shelford, another authority on these insects, that the American elision of the significant first syllable to give them the name "roach," already appropriated for a fish is highly reprehensible.

What is the secret of the success of the Common and the German Cockroach, not to speak of the others, in countries, like Britain, to which they are certainly not native? Our three indigenous cockroaches (Ectobius) that live out of doors are much less successful and are practically negligible. The success of the naturalised aliens depends on a variety of qualities. They are nocturnal in their operations; they run very quickly, they are able, because of their much flattened bodies, to get into almost inaccessible crevices; and in becoming domestic they have got away from their natural enemies. Another quality of great survival-value is their wide range of appetite. As Mr. Frederick Laing says in his admirable British Museum pamphlet, *The Cockroach* (1921): "Nothing which is at all edible comes amiss to them in the way of food. The paper or the whitewash on the wall, books, boots, hair, are all eaten as readily as the daintiest dish." They are very fond of good beer. In a well-known book on the cockroach by Professors Miall and Denny it is observed: "Cucumber, too, they will eat, though it disagrees with them horribly." They have been

known to try ink and blacking ; they devour their own cast-off clothes (or moults), their own empty egg-capsules, and their own dead ! As long as they are not full-grown, they have this further advantage, that they can regrow their long tactile feelers and their lanky legs if these get broken—provided always that a little stump is left to serve as a starting-point for the regeneration.

As to family matters, the females of the Common Cockroach are about three times as numerous as the males, and have rudimentary wings. The pairing occurs in the summer months, and about sixteen eggs are laid at a time inside a dark-brown egg-capsule, which splits when the young ones are ready to come out. Mr. Laing notices that in most cases only ten or eleven of the sixteen eggs are hatched. The young cockroaches should not be called larvæ, for they are practically miniatures of their parents, though at first very delicate and with hardly any colour. They grow slowly and take about five years to become mature, moulting usually once a year. Perhaps things move more quickly when the conditions are less artificial than those which allow of scientific observation. Not that we wish them to move any faster, for Mr. Laing notes that three females kept in captivity from April to September laid twenty-five capsules. "If we reckon that each laid, on an average, eight capsules, and that out of each capsule ten larvæ emerged, the progeny from a single female would total eighty. The numbers of cockroaches in our kitchens, therefore, can easily be explained."

The German Cockroach is only about half the size of the one we call Common ; it is dark yellow or light brown in colour ; the females have wings as well as the males, and greatly outnumber them. The egg-capsule holds on an average about forty eggs, and it is carried about by the mother for two to four weeks until the young are ready to hatch out. As in the Common species, the capsule breaks and the young ones put their heads out, but there is this difference, that the mother is interested and helps them to escape. The newly-hatched cockroaches are white and cylindrical, able to run about from the first ; they soon

flatten and become dark in colour. Growth is rapid, and after about five months and as many moults (with a return to the white colour at each disrobing) maturity is reached.

Perhaps there is not much of the romantic about "blackbeetles," but their repugnant smell and taste, due partly to the salivary juice and partly to wax-glands on the body, forbid impartiality. We say "taste" because it is notorious that they contaminate food carelessly left exposed. But no unprejudiced eye can call them ugly, and a green species we once got in a bunch of bananas was a truly beautiful insect. There is interest also in the glimpse of maternal care that we get in the German Cockroach, pointing on to another kind, that Mr. Shelford tells us of, which carries about its lately hatched young ones.

The voracity of cockroaches, their contamination of food, and their repulsive smell, mean big black marks against them, and Mr. Laing notes in his excellent sixpennyworth that "their presence in greater or lesser numbers may produce such a mental effect upon the inhabitants of a house as to react detrimentally upon the general health and well-being." He tells us how they may be kept in check by means of traps and an excellent mixture of sodium fluoride and pyrethrum powder. But there is a broader way of looking at the matter, namely, that cockroaches are disposing of "crumbs" (in the wide sense) which are quite gratuitous, and that they are often sheltering in crevices which need not be there. They are comparable in a way to invertebrate rats. Though they have not been convicted as yet of being the vehicles of any disease that affects man, Mr. Laing tells us that the Common Cockroach serves as secondary host to a bacillus which produces cancer in rats.

Although there is very little to be put on the plus side of our account with cockroaches, unless it be that they prey upon bed-bugs, we have reason for congratulating ourselves in one respect that the Golden Age of cockroaches is over and gone. For they are insects of long pedigree, and they were at their climax at the time of the Coal Measures. In his fine Ray Society monograph on British Orthoptera (1920), Mr. W. J. Lucas writes: "Since Palæozoic times cock-

roaches appear to have decreased in *numbers* greatly, if not so much in *size*, and they must now be looked upon as but a dwindling remnant of a dying race. Let the careful housewife find in this fact what consolation she can : at any rate she may rejoice that the Carboniferous period is past, and that she is not required to combat the host of cockroaches which luxuriated in the warm, moist climate of that far-distant age."

EARWIGS

We are taking earwigs as representatives of the old-fashioned terrestrial insects. It cannot be said that they are popular animals, but perhaps that is largely due to the prejudice of ignorance. They are neat and alert ; they have a long pedigree ; and they have some rather pretty ways. They suffer from the ineradicable superstition that they creep into the ears of sleepers, and worming their way to the brain grow to a fatally large size, " as big as a goose's egg." This is a widespread piece of nonsense, for the French name for earwig is " perce-oreille," and the German " Ohr-Wurm." The only fact behind the superstition is that earwigs like to snuggle into dark crannies. Most of them avoid the full light of day and are active in the afternoon and evening. One sometimes finds them in considerable numbers by slitting up a hollow stem like that of hemlock, for they enter by a crack and enjoy the dry shelter. This habit is taken advantage of in trapping earwigs, which is effectively done by taking pieces of elder sticks, pushing the pith out, and corking up one end. This is neater than the common device of putting inverted flower-pots, with some hay inside, on to tops of dahlia-stakes and the like. Among their favourite habitats we must include rotting tree-stumps, flat stones lying loosely, and the burrows of earthworms.

It is usually stated that earwigs do a great deal of harm in flower gardens. They are much blamed for nibbling at the petals of flowers, like chrysanthemums, dahlias, and phloxes, and gardeners dislike them accordingly. They

are also accused of devouring buds, as in the case of hops, and of spoiling fruit. No doubt many of them have a sweet tooth, but we share the heretical view that earwigs are not so injurious as is usually alleged. In many cases they are searching the plant for soft-bodied destructive insects like thrips and green-fly. The common earwig (*Forficula auricularia*) eats the tender shoots of grass and clover, and attacks dahlias and roses and other flowers, yet even in this case the full-grown individuals certainly enjoy insects. There is a seashore earwig, differing from most of its relatives in not disliking the water, and it is well known to devour both living and dead animals. It is clever in catching sand insects, and it will clean up a dead crab or fish. We are not saying that earwigs do no harm, but merely affirming that they are sometimes carnivorous or omnivorous.

Earwigs are old-fashioned insects in the order Dermaptera, not very distantly related to the cockroaches and crickets and other members of the order Orthoptera. The front wings or wing-covers are short and leather-like, and neatly folded beneath them there are in many cases relatively large membranous wings, which can be used in flight. There is a beautiful fan-like folding into small compass, so that they can be tucked very compactly beneath the wing-covers. These well-developed wings can be readily seen on the common earwig, which is one of the most abundant insects in Britain, yet very few people have seen the creature flying. It is probable that in the majority the neatly folded wings are never unfolded at all. There are many kinds of earwigs which have lost their wings altogether, and have thus returned, like some beetles, to the wholly terrestrial life of the ancestral insects.

A point of some interest is the superficial resemblance or "convergence" between many of the earwigs and certain beetles or Staphylinids, though there is no relationship between them. In both we see an elongated form of body, an exposed abdomen, short legs, much reduced wing-covers, active movements, avoidance of light and scavenger habits. But there is one very obvious difference, that ear-

wigs have forceps at the end of their body, and we must say a little about these rather puzzling instruments. The forceps are usually larger, stronger, and more curved in the males, and in many cases there are specific differences between the forceps of the males of related species, while those of the females are indistinguishable. Sometimes there are two forms of forceps in the males of the same species (dimorphism), and there is occasionally a strange inequality in the two blades. They are used in various ways, as weapons, as aids in pairing, and in the folding and unfolding of the wings. The forceps of the maritime earwig can draw blood from man's finger, and they are used in capturing small booty, the body being thrown sideways in a curious wriggling fashion.

Earwigs lay eggs in clusters on or near the surface of the earth, and there may be several broods in the course of the summer. The mother watches over the egg clump, and she continues her care when the young ones hatch out. They are miniatures of the adult, except that they have no wings, and we have seen them run close to the mother when we disturbed them. There is some discrepancy of observation in regard to the degree of the maternal care, and this may be due to differences between the species. It is a matter that should be looked into afresh. There is no ambiguity in what the old entomologist De Geer reported : " At the commencement of June, I found under a stone a female earwig accompanied by her young. I placed them in a sand-box where I had put a little fresh earth, and it was curious to see how they ran under and between the legs of the mother, who remained very quiet and allowed them to do it. She seemed to cover them as a hen does her little chicks, and they remained often in this position for hours. Another time I found a pile of eggs on which the mother was seated, and of which she took the greatest care imaginable without ever moving a step away. I took it with its eggs and placed it in a sand-box half-filled with fresh earth, in such a fashion that the eggs were scattered here and there. But soon the mother took the eggs one after the other in her jaws and transported them. After several days I

spite of handicaps. The fact is that these Lilliputians are highly successful; they are saved by their minuteness, their dislike of the light, their quickness, their crumb-diet; they have found niches of opportunity all their own. This is an aspect of evolution that one is a little apt to forget—the success of the elusive.

CENTIPEDES AND MILLIPEDES

In turning over a heap of road-trimmings by the wayside, or in breaking up a mouldering tree-stump, one always disturbs a crowd of curious creatures. Amongst them one finds a few hundred-footers or centipedes, usually going singly and hurrying off with great celerity when molested. But there are also thousand-footers or millipedes, usually in small companies and leisurely in their movements. If one lays a finger on a centipede, it turns round and bites; if one lifts the millipede, it coils up in a flat spiral like a watch-spring.

To many people there is something repellent in these creatures, which are certainly consummations of wriggliness. Perhaps it is the suggestion of snakes in miniature that raises a prejudice against them, but no one can call them ungainly or their movements ungraceful. Perhaps there is something displeasing in the very frequent repetition of similar rings and limbs, for we do not like the same thing over and over again; and although the names hundred-footed and thousand-footed—centipedes and millipedes—are popular exaggerations, there is often an almost tiresomely large number of uniform rings and legs, or, more technically, segments and appendages. Perhaps the fact that centipedes have poison claws, which sometimes give a painful wound, is sufficient to account for the repugnance with which many people regard them, and it would be natural enough to extend the reproach to the quite innocent millipedes. Some common British centipedes are about an inch and a half long (*e.g.*, Lithobius), and millipedes (*e.g.*, Julus) a little less; but in warm countries both kinds may attain a length of over eight inches. The big centipedes have an aggressive air and look quite fearsome.

When we watch centipedes and millipedes at their ease our first impression is of effective locomotion. The centipedes hurry along almost fussily, and the millipedes are not slow to cover the ground if they are in a mood to do so. Both kinds discover holes where none seemed to exist; they like narrow passages; they wriggle their ringed bodies round rectangular corners; they seem to be able to reverse engines and move tail foremost. What we see is a rowing upon the ground or in the soil, with the multitudinous legs for oars. Each multipede is like a subterranean galley. The legs of ordinary millipedes are too small for observation on the roadside, but one can readily convince oneself that those of a centipede work in relays, and that when those of one group are pushing backwards against the ground, those of the adjacent groups are being moved forward to take grip for another leverage. The movements are so quick that it is difficult to be sure, and it is rather a relief to remember that the most distinguished of zoologists, Sir Ray Lankester, found it difficult to analyse the order of the centipede's going. He came to the conclusion that if the animal had to work out the problem for itself, it would never get on at all! He quoted the lines, "The Centipede's Problem":

"A centipede was happy quite
  Until a toad in fun
Said, 'Pray, which leg moves after which?'
This raised her doubts to such a pitch,
She fell exhausted in the ditch,
  Not knowing how to run."

But the main fact is that the numerous jointed legs, which are full of muscle, are used like oars to row the animal forward. And what a pace the centipede gets up! It reminds one of a miniature railway train.

When we look hard at these wriggling centipedes and millipedes we see that while they are somewhat like one another in being light-avoiding, many-legged, many-ringed burrowers, they are really very different. The centipede's body is flattened from above downwards; the millipede's is cylindrical. The centipede has a pair of legs on each ring; the millipede has two pairs. Indeed it looks as if the

adjacent rings on the millipede's body had coalesced in two's. In the centipede the feelers or antennæ are long and many-jointed; in the millipede they are short and few-jointed. The centipede has the first pair of legs turned into poison-claws; the millipede has no such appendages, and is quite harmless as far as wounds go. The mouth-parts of the two types are very different; and whereas the female centipede lays her eggs posteriorly, the corresponding aperture is situated anteriorly in the millipede.

We have mentioned these details, which might be added to, because they let one into a zoological secret and open up an interesting problem. The fact is that the more we study centipedes and millipedes (often slumped together as Myriopods), the more do differences multiply. The secret is that these two sets of animals are in different classes, not nearly related to one another. The likeness is technically called *convergence*, a term used when a superficial resemblance is exhibited by unrelated animals because they have become similarly adapted to similar conditions of life. Centipedes and millipedes are not closely akin; yet they have an undeniable likeness; this is because both have become suited to progression through holes and crevices. Porpoise and shark are somewhat like one another, being suited in their stream-lines to rapid swimming, but the first is a mammal and the second a fish. Of course, centipede and millipede are not nearly so far apart as mammal and fish; but they are farther apart than are swifts and swallows, which belong to quite different orders of birds.

We have referred to the different behaviour of the two animals when they are molested. The centipede is more highly strung; it rushes off; it turns and bites. It is a self-possessed, vigorous hunter. The millipede is somewhat lethargic; it "feigns death" or "plays 'possum"; it curls itself up; its only retaliation is to exude from pores along its sides an oily fluid with a repulsive smell. It is a peaceful vegetarian, often inclined to be gregarious.

Our third note is severely practical. The gardener sometimes destroys centipedes and millipedes indiscriminatingly, but this is a mistake. For centipedes are carnivorous and

keep a check on many injurious insects, whereas millipedes are vegetarian and often do harm in the garden. In warm countries there are often big millipedes ; but they need not be dreaded as big centipedes should be. The fact is that centipedes and millipedes are on quite different lines of life. They are literally on a different footing.

A little more must be said in regard to the way in which the life-circles of these multipedes intersect the life-circle of the supreme biped. The " bite " of a big centipede (from the first pair of legs) means an injection of poison, which causes pain and swelling. There is some definite influence on the nervous system, for the patient often suffers from dizziness and headache. Centipedes resemble earwigs in their inclination to move into narrow passages which touch many parts of their body. This constitutional peculiarity may account for the fact that they occasionally find their way into man's nostrils. Both centipedes and millipedes may occasionally live for some time in the human food-canal into which they have been obtruded by careless eating.

Many millions of years ago when the ancestors of our earthworms discovered the underground world, they entered upon a Golden Age of peace and plenty. But this was too good to last, and among the first to follow the earthworms into the underworld were the centipedes—predatory, bloodthirsty, and pertinacious. The ancient feud has persisted through the ages, and it may be watched to-day by the wayside. The centipede attacks the earthworm, clinching its poison-claws. The poison seems sometimes to paralyse the earthworm, for it lies quiet ; but in other cases there is a convulsive wriggling, and the Annelid (or Ringed Worm) may throw off the Arthropod (or Jointed-footed Animal), hurling it for some inches along the ground.

But the centipede returns to the attack, and, with or without a further injection of poison, bites the earthworm with his mandibles or jaws, which are cutting-blades without venom. It seems to chew through the body-wall, pressing its mouth-parts close to the victim. In some cases it makes numerous bites near one another, so that a portion of the earthworm's body is separated off. The centipede chews

this booty at leisure, while the rest of the earthworm crawls away disconsolate. Perhaps there may be a fatal bleeding; perhaps a fly may deposit eggs in the wound, and the last state of the earthworm will be worse than the first. But it may be that healing processes begin, and the earthworm may re-grow a new tail to replace what it has lost.

One can understand how any little improvement might turn the scales. More virulent venom might give an easier victory to the centipede; increased re-growing power might enable the earthworm more readily to survive considerable curtailment. The nimbler the centipede, which does not hesitate to follow the earthworm into its burrow, the more successful it will be as a hunter; but a very sensitive and muscular nullipede (the earthworm) may succeed in parrying the thrust of the multipede (the centipede). Even the worm will turn and toss a centipede, or coil round it like a boa constrictor.

XXIV

WAYS OF CRUSTACEANS

WHILE Insects are very largely creatures of the air, as the general possession of wings indicates, the Crustaceans, *e.g.*, crabs and lobsters, shrimps and prawns, are mostly aquatic animals. The limbs or appendages are often paddle-like and suited for swimming; almost all the higher forms, like crabs and crayfishes, have feathery gills for breathing the oxygen mixed in the water; the husk or cuticle contains carbonate of lime as well as chitin, and is moulted periodically as long as growth continues. A crustacean has typically two pairs of feelers or antennæ, whereas an insect has one pair, and a spider or any other Arachnid has none at all. The life-history of crustaceans is often very intricate, showing remarkable metamorphosis.

The higher Crustaceans have (except in one family) nineteen rings or segments in their body, *e.g.*, lobster, cray-fish, shrimp, sandhopper, wood-louse. The lower Crustaceans, usually much smaller, differ greatly in the number of segments and appendages, as in water-fleas, brine-shrimps, barnacles, and acorn-shells.

THE FRESHWATER CRAYFISH

Most of the backboneless animals that have found a home in fresh water are small—such as water-snails, water-beetles, water-fleas. But the crayfish, whose name is said to be derived from the French *écrevisse* (this looks too neat to be true), is three or four inches in length. It is exactly like a miniature lobster, usually of a dull greenish or brownish colour, often diversified with a little pale yellow below, and sometimes with a little red about the legs. There is a good deal of variability in the colouring. The pigment is

the same as the lobster's, blue-black, which turns red when boiled. Critics sometimes blame Victor Hugo for calling the lobster "the cardinal of the sea," but he was probably thinking of the Rock Lobster (Palinurus), which is often very ruddy. It is common off the French coast. The same pigment that is bluish in the Common Lobster (Homarus) is reddish in the prawn, and it is called "zoonerythrin," or "animal-red." Chemically considered, it is almost the same as the carotin of carrots. It is well seen in the handsome Norway lobster, which fishermen call the sea-crayfish.

The true freshwater crayfish is common in rivers in many parts of the Continent, and is a much-prized delicacy; it occurs in some English rivers, such as the Thames and the Isis; it is not known north of the Tweed, but it occurs in Ireland. It must be regarded as derived from a marine ancestral stock, and the same is true of the freshwater crabs that occur here and there, though not in Great Britain. Similarly, the freshwater slater (Asellus) has been derived, no doubt, from an ancestral stock on the seashore, and the land-slater or wood-louse has gone one better in becoming thoroughly terrestrial.

The crayfish hunts by night and hides by day. It is made uncomfortable by the glare of the sun, yet it seems compelled to draw to a torch or lantern by night. In a Continental river that we know, the fishermen believe in using a flare when they work something like a shrimp-net from the boat at night.

The crayfish makes long burrows in the banks of the stream, and it sometimes lurks in the entrance during the day, with its great claws ready for some passer-by. All is grist that comes to its mill, from worms to young water-voles, from the stone-wort (Chara) in the pool to the roots of plants growing on the banks.

The crayfish has four pairs of walking-legs, six of which are always on the ground at the same time when it is walking; the first three pairs pull the animal forwards, those of the fourth pair push it. It feels its way in the dark by means of two pairs of antennæ, and at the base of the shorter anterior pair there is a balancing ear. If both ears are injured the

crayfish will swim upside down. On these shorter antennæ there are smelling-bristles, and there are taste-bristles near the mouth. For daylight use there are two pairs of stalked compound eyes, which form an erect mosaic image, very different from the inverted single image formed on the retina of a backboned animal's eye. We see, then, that the crayfish is well equipped with senses, but it seems to be deaf.

Besides walking, the crayfish has another quite different means of locomotion—by swimming. When it is in danger, which it detects by sight, or touch, or smell, it jerks its tail vigorously downwards and forwards, and thus drives itself through the water. It does this very smartly, but it cannot keep up the tail-strokes for any length of time. We understand, then, that it walks head foremost and swims tail foremost!

If one takes a vigorous crayfish and holds it on its head on the table, making a little foundation by broadening out the nippers or forceps horizontally, the creature passes into the strange state called animal hypnosis. It stands stock-still on its head, and remains motionless for a considerable time. We have seen it stand for five minutes on a class-room table. As one held it, of course without hurting it, one felt the muscles of the tail trying to move, but one did not permit the movement. Commands come from the brain, but the muscles are not allowed to obey; and the result of this contradiction in terms is fatigue of the nervous system and rigidity of the muscles. Animal hypnosis is next door to animal catalepsy, but it is not quite the same. A similar state may be induced in frog and fowl, in the edible crab, and even in a guinea-pig; but the meaning of it is not yet clear. It was the basis of the trick that the magicians played before Pharaoh long ago, when they turned rods into serpents. That was because they had previously turned serpents into rods! By and by the crayfish comes to itself again, topples on to its feet, and walks quickly away. We do not suppose that the crayfish ever passes into animal hypnosis in natural conditions, but it does something almost as remarkable—it gives off a limb to save its life.

In autumn the mother crayfish makes a temporary basket

by bending her tail forwards, and into this the eggs, like small unripe white currants, are liberated. At the same time some glue is secreted from the underside of the tail, facing into the interior of the temporary basket; and the eggs are thus firmly fastened to the small paddle-like limbs called swimmerets. There they are fertilised by the male crayfish; and there, in safety, they undergo their slow development, for they are not hatched until early in the following summer. When the female is carrying the eggs, she is said to be "in berry."

In the life-history of freshwater animals there is always a risk of the juvenile stages being swept down to the sea. One way of meeting this risk is to have suckers and grappling structures; and the young crayfishes have the tip of their great claws turned in, and the ends of the last two "walking legs" hooked. These inturnings and hooks make it easier for the young ones to grip the mother's swimmerets or the empty egg-shells which are still glued on. Another way of meeting the risk of being swept away is to telescope or shorten down the juvenile stages; and this is very marked in crayfishes, for what comes out of the egg may almost be called a miniature of the parent.

SHORE-CRABS

Some animals are safe because of their armour—hedgehogs, for instance—but have little in the way of weapons. Others are safe because of their weapons—cuttlefish, for instance, with their grappling arms and parrot-beak-like jaws—but have little in the way of armour. But crabs illustrate an admirable combination of offensive and defensive equipment. Their forceps or great claws are effective weapons, giving a shrewd nip; their shell of lime and chitin is effective armour. They have their enemies, such as cuttlefishes, but their foothold in the struggle for existence is very secure. The seashore is no place for the ungirt loin, no place for "slackers," and we get a glimpse of the keenness and subtlety of the struggle for existence when we notice how crabs, well equipped as they are, add to their security of tenure by many inventions.

In the case of the common shore-crab (*Carcinus mænas*) we often find in the young stages a remarkable harmony of colour between the shell of the animal and the surface on which it creeps. According to the nature of the rocks and the encrusting calcareous Algæ that grow on them, different shore-pools have different hues—reddish, greenish, greyish, and so on ; and the young crabs, no bigger than the nail of our little finger, that live in these pools often defy detection. Until they move they are part of the scenery of the pool, and we do not see them easily even when we stoop down and stare. The exact manner of the colour-change is not as yet very clear.

It must be understood that the small, yet fully formed, crabs we catch on the shore, and return to their pools, have a long history behind them. The eggs which the mother-crab carries about underneath her tail hatch out into pin-head larvæ which are swept out into open waters. They are too delicate for the rough-and-tumble life among the rocks. They pass from stage to stage, and when they have at length become miniature crabs, they cease to be surface-swimmers, and creep up the slope on to the shore.

In the case of the Sand-crab (*Hyas araneus*) and the Narrow-Beaked Crab, we often see what is called " masking " or disguise. It tempts one to think generously of the crab's brain. The creature takes pieces of seaweed, nibbles at them a little, and then rubs them on the back of the shell, where they catch on tiny bristles. Thus the crab practises the " Walking Wood of Birnam " trick, and goes about well-disguised with a little garden on its back. Sometimes it uses pieces of sponge and zoophytes and other animals, always cloaking its reputation, for the crab must have something corresponding to a reputation on the seashore. In an aquarium, crabs sometimes put on a garment which makes them more conspicuous, such as pieces of brightly coloured silk which are given to them to play with. They have to obey the instinct to cover themselves, and we must not make too much of the fact that in quite artificial conditions their instinct sometimes leads them astray.

HERMIT CRABS

Many a one watching a seashore pool for the first time has had the pleasant and unforgettable surprise of seeing what looked like an empty shell of a whelk or a periwinkle suddenly unfold itself into a hermit crab and scuttle away. It is curious indeed that a member of a well-armoured class—that of the Crustaceans—should have acquired the habit of borrowing the defences of an entirely different kind of animal—a Mollusc. The present-day need for the borrowing is plain enough when we see the hermit crab's tail, for it is soft and flabby, without the usual number of limbs, and very much in need of protection. And just as the caddis-fly larvæ in the stream encase themselves in cleverly built tubes of cemented pebbles or tiny pieces of stick, and just as some crabs mask themselves with seaweeds and sponge and such-like things, so the hermit crab makes up for what is much more than " a joint in its armour " by borrowing the substantial shell of some sea-snail, which serves at once for protection and for disguise.

The habit must be of very old standing, for there is hardly a part of the hermit's body that has not been changed in some way or other so that it suits the better the hermit's cell. Thus the rather ungainly tail has a peculiar banana-like twist which suits the shell's coil ; of the six posterior limbs which the tail ought to bear, none are strong save the two last, which grip the central pillar of the shell so that it is not easy to pull the hermit out ; on the right side of the tail only one limb remains. One of the great forceps, which are so important in seizing food, in fighting, and in guarding the door of the retreat, is in many hermit crabs much larger than its fellow on the other side. We need not go further, but it is important to understand that the hermit's body is suited in a through-and-through way to the shell which he carries with him.

Let us turn to the animal's habits, and especially to those of the " soldier " hermit crab (*Eupagurus bernhardus*), which have been carefully studied by Mr. Gordon Jackson. One of the old naturalists, Swammerdam, who wrote a great

book called *The Bible of Nature*, was very positive that the hermit crab made the shell in which it lives, but this was a big mistake, for the shell is either found or stolen. Some say that the hermit crab does not hesitate to oust the rightful tenant from a coveted mollusc shell, but this has not been clearly proved. It is possible that it sometimes cleans up the remains of a whelk whose head and foot have been bitten off by a cod or some other voracious fish.

Every now and again the hermit has to leave his cell, for he has become too large for it, and he is very nervous at the time of flitting. Some one has compared him to " a bather whose clothes have been stolen," and Mr. Gordon Jackson contrasts his nervous anxiety before he finds a shell to vault into (for he is quick about it) with his " sleek impudence on safely reaching the desired covering."

The hermit crab has a large and varied appetite. There seems to be almost nothing—animal or vegetable—that is not eagerly eaten. The great forceps are important in seizing the food and carrying it to the jaws and the foot-jaws, which shred it or pound it. Thence the food passes into a wonderful internal mill or gizzard, almost the same as the corresponding piece of machinery in the crab or lobster.

When we watch hermit crabs in a shore pool—an entertaining way of spending an afternoon—we cannot but form a high opinion of their capacities as alert and nimble creatures—nimble in spite of the heavy burden which they have to carry about with them. They are notoriously combative, always on the outlook to find a neighbour rather too far out of his shell. The thrust is usually parried, there is instantaneous withdrawal into the recesses of the shell, and the bars of the door go home with a click. Sometimes, however, one combatant succeeds in pulling the other right out of its shell. In encounters with one another and with enemies beyond their kin, a limb is sometimes lost or badly damaged, but this matters little, since, as in many Crustaceans, there is more or less perfect regrowth at the next " moult " or cuticle-casting. In leaving its old clothes, the hermit crab first gets its head and breast disengaged, then its front

limbs, and finally its tail. It must be remembered that the soldier hermit crab which ends by being big enough to fill the great whelk or "Roaring Buckie" has, in the course of its life, experience of a considerable variety of lodgments—such as the turret shell (Turritella), the top shell (Trochus), the periwinkle and the dog-whelk.

The hermit crab enters into association with a number of other animals in addition to the Mollusc, whose empty or emptied shell it tenants. Thus there is often on the surface of the shell a colony of interesting zoophytes, called Hydractinia, and not infrequently a growth of sponge. Round about one of the hermit crabs (*Eupagurus prideauxii*) common in the Firth of Clyde there is always a sea-anemone (*Adamsia palliata*), and the two creatures are never found apart. The hermit crab is cloaked by its partner, and probably profits also by its stinging power; the sea-anemone has the benefit of being carried about and of feeding on the crumbs from the crab's table. It is a mutually beneficial partnership, and it is interesting to note that when the crab leaves its shell to enter a new one, it takes its partner with it. In the case of the soldier hermit crab there is often a rather quaint partnership which is beneficial on one side only. A many-legged bristle-worm, called *Nereis fucata*, shares the hermit's cell. Mr. Gordon Jackson writes: "It usually remains out of sight in the back whorls of the shell, but it appears at meal-times, thrusting its head out between the crab's foot-jaws to appropriate the very morsel on which its host is engaged."

As to the hermit crab's life-history, the mother carries thousands of eggs (12,000–15,000) fastened to the bristles of the tail appendages. There they develop into tiny free-swimming larvæ, called Zoëæ, which live in the open sea. After several moults and changes, they become what are called Glaucothoës that prowl about at the bottom of the sea during the day and rise to the surface at night. It is during this stage that they seek out houses and begin to become "hermits"—though that is anything but a good name for them, for the hermit crab is a born hustler.

THE PROCESS OF MOULTING

Among the jointed-footed animals, like insects, spiders, crustaceans, the life-history is, so to speak, punctuated by the frequent occurrence of a remarkable process called "moulting." Every one knows how mammals cast their hair, especially at certain seasons, and how birds moult their feathers, and there is the less familiar "sloughing" of snakes. As these changes of dress differ not a little from the shedding of the old husk that is seen in Arthropods or jointed-footed animals, there is some need for a special name, and the word used in reference to Arthropods is "ecdysis." The use of a special technical word is to avoid calling different things by the same name, which always leads to confusion of thought and blurred pictures. We need not use the word "ecdysis" if we clearly understand that what a crab or a caterpillar or a growing spider throws off when it "moults" is a husk or cuticle that never had any life in it, whereas hairs and feathers and sloughs were for a time built up of genuinely living cells. A true cuticle is a protective outer layer, without cells and without life, which is made and also remade by the underlying living skin. It has to be thrown off because it cannot grow.

The first animals to show clear casting of the cuticle are the threadworms or Nematodes, whose skin is covered with a firm, glistening, non-living membrane which does not allow the animal to grow larger after it becomes firm. But much better illustrations are found among the jointed-footed animals, where the cuticle is much thicker and firmer than in the threadworms. In centipedes, insects, spiders, and scorpions, the cuticle is made of a very resistant material called chitin; in crustaceans this chitin is usually strengthened with carbonate of lime, as in crabs and lobsters which are very strongly armoured. As regards insects, except in Mayflies, there is no moulting after the wings are formed, for there is no more growing after that. In other words, insects do their growing and moulting when they are young, and that usually means in their *larval* stages, when they are, for instance, caterpillars, grubs, or maggots.

A caterpillar often moults five times, but a butterfly or moth is free from all trouble of this kind. In insects like locusts, grasshoppers, and crickets (Order, Orthoptera), there is no worm-like larval stage, but what comes out of the egg is, on the whole, like the full-grown creature, except that there are no wings. There is rapid growth and a succession of moults; but in the final full-sized stage the wings appear (unless it be a wingless Orthopteron), and after that there is no more moulting. The important big fact is that moulting or ecdysis is necessary because the cuticle cannot grow in a living way and has very little power of expansion in a non-living way. If the animal grows there must be moulting, and there is a spurt of growth after each moult, before the new cuticle has hardened. Compared with crabs and lobsters and other Crustaceans, there is an improvement among insects, for they get done with all their moulting in their juvenile stages. The moulting is part of their "growing pains."

To understand this moulting more clearly, let us take the particular case of the crab, and begin with a common seashore experience. When we lift seaweed, or shift and replace stones in a shore-pool, we sometimes disclose a miniature cave in which there seem to be two shore-crabs differing slightly in colour. If we lift the brighter of the two, dressed in vivid grass-green, we feel its body yielding between our finger and thumb. It is as flabby as wet cloth. It is a newly moulted crab, and the other "crab" is the cast-off shard. It is a case of substance and shadow!

The "moult" of a crab is a perfect image of the crab that has moulted. Every detail is there—the two pairs of short feelers, the husk of the eye, the covering of every limb, and the shard of the whole body. A "moult" may be easily distinguished from a dead crab that has been cleaned up in the sea, for the carapace or shield-portion of the moult divides in your hand unto an upper and a lower half, along a twisted line going right round the body. This is the splitting or moulting line, and its meaning is plain. It is the line of breakage which allows the crab to get its body out. When the animal has managed to clear not only the

broad shield-like carapace portion, but also the tail which was tucked up underneath, the husk falls together again and lies like a ghost of the former tenant. It is a pleasure to pick up the ghost and open it along the clean-cut moulting line, for then one sees that the crab has left behind it the covering of all the numerous gills. One can also see the tendons of many of the muscles. The moulting is very thoroughgoing.

We must understand that the shell or external skeleton of a crab or a lobster is very different from that of an armoured backboned animal like a tortoise. The scales of a tortoise are built up of living horn-making cells which add to the size of the scale as life goes on. But the shell of a crab, as we have already said, is non-living. It is a cuticle, made and remade by the underlying living skin. It is made of the resistant organic substance called chitin, and also of carbonate of lime, which makes the husk still more substantial. Such, then, is the armour in crab and lobster and all their relatives, very strong but not too heavy, very durable, and quite callous except where delicate sensitive bristles project. First-class armour, with well-protected flexible membranes at strategic points, such as the joints of the limbs. But the tax to be paid on this armour is moulting. The animal inside the husk is a growing creature, but the non-living husk cannot grow. The creature comes to be like a young knight condemned to wear the suit of chain-armour which was given to him when he first mounted a horse. The growing crab or lobster is always getting into physiological difficulties ; it is always becoming too big for its clothes. Hence the necessity of moulting ; hence also the spurt of growth that takes place immediately after the casting of the old cuticle, before the new one has had time to harden.

In the case of the crayfish, there are seven moultings in the first year of the animal's life, five in the second, three in the third, and then a further reduction till moulting stops altogether. The meaning of the series—7, 5, 3, 2, 1 is very clear, for the rate of growth is greater in early life. It gradually wanes, and thus the need for moulting occurs at

longer intervals. It finally stops, for growing has stopped. We see crabs and lobsters with clusters of barnacles and other encrusting animals on their shells, proving that there has been no moult for a long time. These big crabs and lobsters have either reached their limit of growth, or they have stopped growing for several years.

As we have said, the moulting of the cuticle is very thoroughgoing. The muscles of the limbs have to be drawn out of their encasements, and the tendons, which are non-living strips of chitin, have to be left behind. The covering of the eye has to come off and the lining of the ear has to be surrendered. The elaborate grinding mill or gizzard, which one finds inside the crab or lobster, arises as an intucking of the outer skin, and it follows that its cuticle-lining, with hard crunching teeth and sifting bristles, has also to be relinquished. As a matter of fact, the lining of the gizzard breaks down and is ejected from the mouth! The internal chewing apparatus, for such it is, has to be made afresh after each moult. All this scrapping and beginning again means an expenditure of vital energy; and it is fatiguing.

Moreover, there is considerable risk of breakage, especially during the extraordinary process of drawing the strong muscles of the limbs through the narrow joints. The difference in architectural idea between the backboned animal and the Arthropod is very striking, for in the former the muscles are outside the skeleton, whereas in the latter they are inside. The skeleton of a backboned animal is a living, growing skeleton; that of a crab or lobster, beetle or scorpion, is non-living and non-growing. Yet if any animals have "growing pains," the moulters must surely have them.

Another aspect of the case is the helpless state of the animal just after moulting. It is soft like wet cloth, and at the mercy of its enemies. Naturally enough it retires from public life at this time and makes the moulting as private an affair as possible. It is safe to say that few people in Britain have ever seen a lobster moult. And apart from these risks, what a state the creature is in! It has lost the covering of the eye, the lining of the ear, and the tendons

of its muscles. It has dismantled its gizzard and given away its jaws. To stand on its own legs is out of the question, so it lies low and says nothing.

Every one who has eaten a lobster knows that the largest single piece of flesh lies in the second-last joint of the great claws or forceps. This is the closing muscle of the formidable forceps and it is of great strength. Similar muscles on a smaller scale occur inside the other limbs—a lobster has nineteen pairs altogether—and the question arises how such relatively big pieces of flesh or muscle can be drawn through the narrow tortuous joints. It is easy for us to draw our finger out of a glove, but suppose the cavity of the glove-finger was interrupted by numerous hard partitions, leaving only narrow gaps! The answer to the conundrum is of great interest. Muscles are composed of elongated living cells, and there is a great deal of water in them. Living matter often contains 90 per cent. of water. What happens before moulting is a great loss of water on the part of the muscles, so that they shrink to a quarter or less of their normal bulk. It is this reduction of size that enables them to slip readily through the narrow passages inside the legs. The old naturalists supposed that the muscles liquefied so that they might pass through the joints; but if they had opened a limb just before a moult they would have seen that what occurs is just the opposite of liquefaction. How much better it is to look than to guess! As Fabre used to say: Look first, and theorise afterwards.

Returning for a moment to the crab and its ghost in the shore-pool, we must ask what happens to them. The ghost or moult is soon washed away and broken against the rocks. We find its minute fragments in the sand. The flabby crab, unable to move or eat, grows at the expense of animal starch and other stores which were accumulated in its body before the moulting began. But the growth must be rapid, for the skin soon begins to secrete a new armour of chitin and of lime. A supply of lime was also laid up in reserve before the moulting crisis, and it is deposited in little patches in the new soft husk. Gradually these patches spread and join together; the chitinous matrix becomes

firm; the crab is once more equipped with first-class armour, and so the story begins again.

THE STORY OF THE FIDDLER-CRAB

Crabs have a very intricate life-history. Whether we take the shore-crab's (*Carcinus mænas*), or the edible crab's (*Cancer pagurus*), or any other, matters little, for the general features are the same. We select the Fiddler-crab (Gelasimus), which is a common shore animal on Atlantic coasts and in the Indian Ocean. The male is a quaint little creature, for one of his great claws is often bigger than the whole of the rest of the body, which is just about an inch across the shell.

In the case of a dog the legs carry the body; in the fiddler-crab the body carries the great claw. Moreover, one's sense of proportion is puzzled by the fact that it is only one of the two claws (usually the right) that is so much exaggerated. When the fiddler burrows into the sand along with his mate he sometimes uses the great claw as a door—a door that can pinch. When he goes on the warpath he brandishes his great claw in the face of rival males. It is like a heavy club. In the Indian Ocean fiddler, according to Dr. Alcock, the great claw is used for exciting the interest of the female. It is bright red in colour—in the American kinds usually white with a few colour-markings—and it is waved about excitedly. So the exaggerated claw may have three uses—as a door, as a club, and as a flag!

The adventurous life of the North American fiddler-crab has been recently studied by Mr. O. W. Hyman, Fellow in Biology of Princeton University, and we wish to refer to some of the interesting facts he has brought to light. There are in North America three different species of fiddler, and the commonest occurs in droves of thousands on the sandy beaches, the coloration of the shell harmonising protectively with the wet sand. Another is fond of a muddy shore and of exploring among the sedges in the adjacent marshland. The third one frequents brackish water, and may be found in ditches two or three miles from

the sea. It should be noticed here that some relatives of the fiddlers have become land-crabs, living in inland places except at the breeding season, when they march in great troops to the shore, returning when the spawning is over. The young ones follow them later on, when they have safely passed through the troubles of their riskful juvenile life. There is another relative which climbs up the mangrove bushes and gnaws the leaves, just as the robber-crab climbs the coco-palms to get the nuts.

The fiddler-crab gets its name because the male carries the great claw in front of the body somewhat in the position of a fiddle, which its shape also suggests. In spite of this burden the animals run very quickly with the four pairs of walking-legs which all crabs possess. But when they are in danger they burrow, and may dig down for a foot or more. Or they may slip down a burrow already made. These burrows are temporary shafts, for the tide fills them up and the walls fall in. But a fiddler-crab cannot be buried alive in wet sand, enough oxygen being always available in the saturating water. They are not given to going into the sea itself, for they cannot swim. But they wander about the shore in search of food, and are fond of walking along the sand-ripples left by the receding tide. They scoop the sand into their mouths for the sake of the minute organisms which it contains. Their enemies are shore fishes and big crabs, but they hold their own in millions. The battle is not always to the strong. The fiddlers succeed because they are small, alert, protectively coloured, quick to efface themselves in their burrow, and able to feed well at a low level, namely, on very minute plants and animals in the sand. But this is not the whole story, for they succeed because they are many.

In early spring the female fiddler liberates the eggs into a basket formed by her broad tail, and there they are glued to the four pairs of tail-appendages and fertilised by the male. They look like numerous "bunches of tiny purple grapes," for the yolk is purple and not yellow. As the embryos develop inside the eggshells, they use up the purple yolk, which is their legacy, and the colour changes to dirty

grey. The mother moves awkwardly when she is carrying all these bunches of eggs, but she is careful to aerate them by standing in the water and jerking her tail up and down. During this period the females spend most of the day in the safety of the burrow. "After dusk, however, they go down to the water's edge with the others when the tide is ebbing." And it is always at dusk that the family is set free. The mother is fanning with her tail as she has done many times before, but this time the minute larvæ are ready to emerge, and at each forward flick of the tail a small spray of young larvæ is shot forward into the water. The mother may go on fanning for twenty minutes before she sets all her children free.

The newly hatched fiddler is much smaller than a pin's head. Its full length is about a millimetre, which is about one twenty-fifth of an inch. In fact, they are just visible to the unaided eye. They are called zoëæ, which means "life," and they swim actively in the water, flexing and straightening their minute body, bending it double in fact. They have two fixed sessile eyes, not on mobile stalks as in the adult, and they always swim in the direction of most light. This brings them to the surface even when it is dusk, and although the surface has all the dangers of a crowded population, there is more food there, and more freshness, too, than on the shore or in deeper water. The mother's behaviour in fanning with her tail is what we call *instinctive*, that is to say, it requires no learning; the larva's behaviour in making towards more light is rather different, the little creature is obeying a useful constitutional obligation just like that which, in unnatural conditions, brings the misguided moth into the candle-flame. This sort of activity is called "tropistic" by those who make a special study of animal behaviour.

In the surface waters the tiny larvæ capture microscopic organisms much smaller than themselves. They feed and grow, and for four or five days they are swept in and out with the tide. But a crisis is not far off; they become too big for their clothes, and they must moult. The husk splits across the back, and the larva wriggles out through the

slit, first the anterior part and then the tail. But the muscles have to be pulled out from within the slender limbs, and the zoëa has seven pairs. It is a fatiguing process, and the larva sinks to the bottom. Out of the old husk comes a second zoëa, a little different from the first, and the first thing it does is to rise to the surface again. The same thing happens over and over again, till a fifth zoëa is formed. But it is not lively like its predecessor; it moves sluggishly and awkwardly near the bottom of the sea; it ceases to be able to move at all of itself, and is simply rolled along by the tide. Its structure undergoes great changes, and out of the husk of the fifth zoëa there emerges, about a month after hatching, a very different creature, called big-eyes or megalops.

This reminds one of a butterfly coming out of a chrysalis, the change is so abrupt. "Instead of being a motionless, sluggish creature at the bottom, the megalops is a powerfully swimming corsair of the ocean's surface." What is it like? About an eighth of an inch long, with an anterior body like a compromise between a crab's and a lobster's, with a tail sticking out behind, but tucked under the body when the creature is at rest. It swims by means of the swimmerets on its tail, and so quickly that few surface animals can catch it.

Balancing organs have now developed at the base of the first pair of feelers, and these make accurate swimming practicable. The pincers are well formed and are effective, both as weapons and as food-catching organs. As Mr. Hyman says: "The food of the megalops consists of any animal small enough for it to cope with successfully. Other smaller crustaceans come within this category, and many a luckless zoëa of its own race falls a prey to the fierce cannibalism of the megalops. The prey is caught and crushed in the pincers and passed back into the grasp of the mouth parts. These prepare it for swallowing. The prey is not bitten into pieces, but rather is mashed until it can be crammed whole into the mouth opening." These details may perhaps sound somewhat unreal to those who are unacquainted with megalopses, but they give a glimpse o

the nicety and subtlety of the intimate life of humble creatures. And there is nothing here that is not in a general way true of the ordinary shore-crab of the British coasts or of the edible crab from deeper water. There, too, we have the larva called zoëa or " life " and the larva called megalops or " big-eyes," both very unlike what they are going to become.

Let us return to the fiddler. The megalops swims for nearly a month, but towards the end of that time the swimmerets on its tail begin to shrivel and the creature seeks shelter in crevices on the floor of the shallow water near shore. There is a critical moult and a little crab emerges which climbs up the slope to between tide-marks. It has little strength and does not venture far out of shelter. But it feeds, grows, and moults—always that logical sequence—and after the third moult, when it is about one-sixth of an inch across its shell, it is recognisable as a young fiddler, and for the first time the males are distinguishable from the females. The eyes are raised on long stalks like periscopes, and the young fiddlers begin to burrow after the fashion of their kind. They feed and grow, and moult many times. If cold weather sets in before they are old enough or strong enough to make a burrow they die of exposure, for all the North American fiddlers have to spend the winter in retirement. What a long and treacherous Mirza bridge the fiddlers have to cross! Little wonder that Nature works with a big margin!

XXV

WORM-LIKE ANIMALS

A GREAT many different kinds of animals have a somewhat worm-like form, as in the common earthworms, lobworms, leeches, and threadworms, but differ from one another in structure to such a degree that it is necessary to make not only many orders of " worms," but many classes. The higher " worms " have their body divided into a series of similar rings or segments, and are therefore called Annelids, from *annulus*, a ring. They include earthworms, seaworms, leeches, and the like. The lower "worms" are unsegmented, except that the body of an ordinary tapeworm is a long series of flat buds. They include threadworms, ribbon-worms, tapeworms, and flukes ; and many of them are parasites, living at the expense of other animals. We cannot do more than select a few representative " worms," beginning with those that are most familiar of all—the common earthworms ; but it should be noticed that many well-known animals, like the sea-mats and the lamp-shells, are grouped by zoologists among " worms," though no ordinary observer sees anything worm-like about them.

THE WORK OF EARTHWORMS

Little heaps of finely powdered earth are a familiar sight on any lawn or meadow, a sign that underneath the grass many tunnellers are at work. In the daytime these tunnellers keep under ground as far as possible, but a visit to the lawn at night with a lantern would give an idea of their numbers. For it is at night that earthworms come out to feed. Many of them do not come right out and crawl about, but keep the ends of their bodies in the safe shelter of their burrows, ready to retire quickly if danger is near. The earthworm's

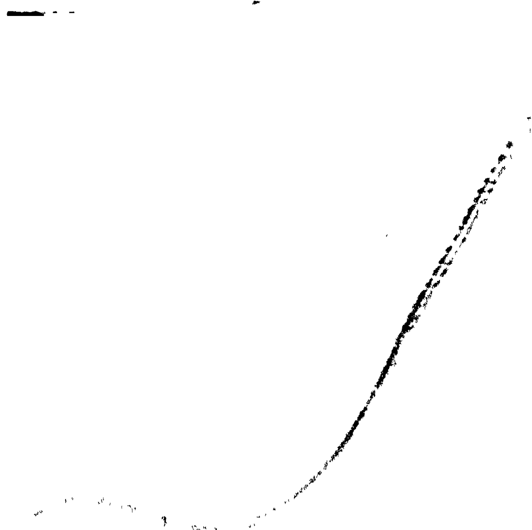


Photo: John J. Ward, F.E.S.

EARTHWORM COMMENCING TO BURROW.

There are many different kinds of earthworms, but the habits are very much the same in every case. In loose soil there is some burrowing of a simple kind, by forcing the particles to the side with the head. But in firmer soil the earthworm must eat its way, and in so doing it utilises the decaying vegetable matter in the soil as part of its food. The head end is more pointed; the tail end is flatter.

body is made up of a great many rings—over two hundred sometimes—and can lengthen out to a surprising extent. So the worm often keeps the tail-end under ground, and, stretching out its elastic body as much as it can, sweeps its head round and round in slow circles. The very sensitive tip of its body forms a rather pointed hood, beneath which is the mouth, and it seeks out leaves and other food materials and helps to drag them back into the tunnel.

The worm draws some leaves over the entrance of its burrow, partly to hide it, but also probably to keep it from becoming too dry, for earthworms, though they are not found in very wet places, require a good deal of moisture.

The burrow runs down several feet into the ground, with its walls made hard and firm by a sticky substance that oozes from the worm's skin. At the end of the burrow there is a slightly enlarged space, and to this chamber the worm brings the leaves. It covers them with a digestive juice, which softens them and makes them suitable for food.

The earthworm is continually tunnelling through the soil. Its sensitive head-end feels the way, and its muscular body pushes the particles of earth aside. It knows when it is near the surface of the ground, for, though it has no eyes, the front part of its body is sensitive to light. It cannot hear the blackbird hopping across the lawn, for it has no ears, but it can feel even the slightest tremor of movement through the soil. In spite of its retiring ways it has many enemies—the birds are quick to snap up any belated wanderers in the early dawn; the active centipedes come prying into the burrows; and the mole, itself a tunneller, breaks into the underground chambers and preys upon the worms as they lie together in a clump on wintry days.

Sometimes the soil is too hard, or too root-bound, for the worm to push its way through. Then it makes its tunnel by eating through the ground, passing the soil through its body. It does this habitually to get food, as well as to make its burrows, but not so much when there are plenty of decaying leaves to be found. It takes the soil into its mouth, and it passes down the gullet into a little swollen sac, called the crop. Beyond the crop is the gizzard, which

not only has hard, muscular walls but also often contains tiny stones. The gizzard is an effective mill. Here the soil is rubbed and crushed into a fine powder, which then passes down the remaining part of the food-canal. Particles of plants or animals are digested in this part, but the soil itself is of no use for food, so is forced out at the end of the body. This fine soil, which has passed through the whole length of the worm and become mixed with digestive juices, forms the tiny heaps, or "worm-castings," seen near the mouths of the burrows.

The work of earthworms is of the greatest importance to man. The small amount of damage they do in nibbling the green corn or sampling the carrot-tops is insignificant, insect larvæ and slugs are responsible for far more of that, and, in any case, it is a small price to pay for the services of the worms. Not that they are intentionally helping mankind—they are simply leading their natural lives, and it so happens that their ways are of great benefit to us. They are by far the most important ploughers of the earth. It is true that there are larger animals, such as field-mice and moles, constantly tunnelling in our agricultural land. But the sum total of their burrowing does not begin to compare with the results of the work of the thousands of earthworms in every acre of the fields.

It is to the careful and patient observations, experiments, and calculations of Darwin that we owe our knowledge of the part played by earthworms in making the earth fertile.

By their tunnelling the earthworms are continually loosening the soil. Air and raindrops can enter by the burrows, and plant-rootlets can find their way down to a depth where they secure the food-materials and moisture they require. Plant growth is increased by the presence of leaf-mould. As we have seen, the worms bury leaves, and the digestive juice with which they cover them helps to change them into a rich mould, which makes the soil more fertile. After a time, discarded worm-burrows lose their firmness, crumble, and fall in. This causes movement in the earth, and exposes new parts to the action of the rain and air. Minute particles in the soil are set free by the bruising in the

mill of the gizzard, which brings about a closer mingling of different elements. Worm-castings form a manure for the grass. In the course of time, the continual eating of soil and bringing the castings up to the mouths of the burrows means that the whole surface is gradually covered with a fresh layer of soil—rich, finely powdered soil—turned up by the little ploughers.

The work of the earthworms may be summed up in three words: burrowing, burying, bruising. It is not easy to realise how such small creatures can have such results as are claimed for them. Gilbert White wrote in 1777: "Earthworms, though in appearance a small and despicable link in the chain of Nature yet, if lost, would make a lamentable chasm. . . . Worms seem to be the great promoters of vegetation, which would proceed but lamely without them. . . . The earth without worms would soon become cold, hard-bound, and void of fermentation, and consequently sterile. . . ." He pointed out in a general way the importance of the burrowing, burying, and bruising; but Darwin's exact observations show more fully how great results may be reached by the accumulation of many small efforts.

Darwin made many experiments with earthworms which he kept in large flower-pots in his study. He watched how they tackled their food, what kinds of plants they liked best, and how they dealt with different shapes of leaves, and what effect the digestive fluid which they secreted had on various kinds of leaves. He noticed when the worms were most active; and how much soil passed through their bodies in a certain time, and so on. He checked these observations with others made by lantern-light out of doors.

He estimated that there are on an average 53,000 earthworms in an acre of garden ground, and about half that number in open fields. If we can realise such figures, we begin to understand the importance of the burrowing, burying, and bruising carried on by these thousands of worms.

To show how the surface of the earth is changed by the earthworms' work, other observations were made. Marked

stones were watched, and the rate at which they sank into the ground was noted over periods of many years. Why does a big heavy stone sink down more slowly than a small thin one? Earthworms dislike cold, and if a big stone is too thick for the sun's rays to penetrate, the ground underneath is cold, and no worms are found there. Under a flat stone they congregate because of the warmth, and make burrows there, which fall in after a time, so that the stone sinks.

Part of a field was covered over with lumps of chalk, and left untouched by man for thirty years. But the earthworms continued their work and at the end of the thirty years the layer of chalk was seven inches below the surface. A well-known example is the story of the "stony field," a very rough field, covered with hard flint stones. It also was abandoned for thirty years, after which, we are told, a horse could gallop from end to end of the field without striking his hoof against a single stone!

Worm-castings, from marked squares of land in different kinds of country, were collected daily for a year, and dried and weighed. The castings from one square yard for one year were found to weigh three-and-a-half pounds. The amount of earth brought up to the surface on an acre of similar ground in a year would be seven tons.

Another of Darwin's figures was that in garden ground fresh mould was brought up to the surface at the rate of three inches thickness in fifteen years. When we hear that his estimate of the amount of earth that passes every year through the bodies of the earthworms of England was 320,000,000 tons, we realise our dependence on worms for soil-making and soil-improving, and can imagine how poor the crops must be in those parts of the world where earthworms do not flourish. But they are found in almost every region of the globe, up to a height of about 10,000 feet. They do not, however, thrive in very hot climates, owing to the dryness; or in very wet places, where they are apt to be drowned; or near the salt spray of the sea.

Many other observers have followed Darwin's example, and given us very striking figures concerning the effect of earthworms on the earth. For instance, in one very fertile

and healthy district of West Africa worms are very abundant, and it was calculated that every particle of soil to the depth of two feet was brought up to the surface once in twenty-seven years, which means very effective natural ploughing.

Darwin's own summary shows how important a factor earthworms have been in the progress of the world : "When we behold a wide turf-covered expanse, we should remember that its smoothness, on which so much of its beauty depends, is mainly due to all the inequalities having been slowly levelled by worms. It is a marvellous reflection that the whole of the superficial mould over any such area has passed and will again pass every few years through the bodies of worms. The plough is one of the most ancient and valuable of man's inventions ; but long before he existed the land was in fact regularly ploughed, and still continues to be thus ploughed by earthworms. *It may be doubted whether there are many other animals which have played such an important part in the history of the world as these lowly organised creatures.*"

SEA-WORMS

In earthworms and their relatives in fresh water there are no limbs or appendages, though there are traces of these, perhaps, in regularly arranged groups of bristles. But in many of the ringed sea-worms there are paired, somewhat paddle-like appendages on most of the rings of the body, and these bear very numerous bristles. As these are finely marked with microscopic lines the light that falls on them is broken up and shows iridescent colours. The finest exhibition of these is the sea-mouse (Aphrodite), whose back is covered with felted bristles or "hairs," and when the animal is in the water it shines like a piece of rainbow. There are a great many of these marine worms, which are called Polychæts (meaning *many* bristles) in contrast to the Oligochæts (meaning *few* bristles), which include all the earthworms and ordinary freshwater worms. As examples of the common sea-worms we may mention the fisherman's lobworm (Arenicola) and the sand-worm (Nereis). Many of them live in tubes.

A very interesting Polychæt of the coral reefs is called Palolo. It is famous for its *periodic* multiplication. In the Palolo (*Leodice viridis*) of Pacific coral reefs, the reproduction occurs at the last quarter of the moon in October and even more markedly at the same time in November. The head-end of the worm is kept fixed in the crevices of the coral, while the posterior body, laden with germ-cells, is broken off and set adrift. These headless sections of worms burst in the water, liberating the germ-cells. For a short time the sea is green with " worms," like thick vermicelli soup, and the eye cannot penetrate below two or three inches. The natives collect the delicacies and have a great feast, and even the land-crabs arrange a visit to the worm-strewn beach. The fertilised egg-cells develop into free-swimming larvæ. Many perish, of course, but there is a large margin of safety. The head-ends in the coral are also able to regrow what they have set adrift. There is an evasion of death, which is often incident on giving origin to new lives.

The Atlantic Palolo worm (*Leodice fucata*) of Samoa and the Fiji Islands behaves in much the same way, but its date is different. The swarming usually occurs within three days of the last quarter of the moon between June 29th and July 28th. According to Dr. A. G. Mayer's description, the mature worm backs out of its burrow, two fathoms down in the coral, and liberates its posterior segments—salmon-red or dull pink in the male, greenish-grey or drab in the female. These swim to the surface and wriggle about there, hind-end foremost. " When the sun is about to rise, and the first faint rays of light fall over the ocean, the worms begin to contract violently "—so violently that they burst. Light is not the sole, but a contributory cause of the muscular spasms. It may be noted that when the third quarter of the June-July moon falls late in July, the Atlantic Palolo has an earlier swarm at the first quarter. The distantly related Japanese " Palolo " swarms at the time of both the new and the full moon in October and November, and there are other cases of bi-lunar, apparently tidal, periodicity.

Dr. Mayer made two very interesting experiments. Thirty days before swarming was due he put some pieces of

rock with eleven worms in them in a scow-shaped live-car, which was floated, half-full of water, on the sea. In this artificial " tideless " sea only four of the eleven worms swarmed. This proved that the Palolo worms *can* swarm without the immediate influence of the tides, but it is quite possible that those that swarmed in the box had previously acquired a tidal rhythmicity—an engraining or enregistering well illustrated by another worm, Convoluta. Perhaps, as Dr. Mayer suggests, the other Palolos in the box would also have swarmed if the circulation of water had been more perfect. In his second experiment Dr. Mayer provided the scows with light-tight wooden covers. The moonlight was thus excluded, and out of twenty-two worms none swarmed. This suggests that the moonlight is a necessary liberating stimulus. Unfortunately, if one may so say, subsequent experiments by Dr. Treadwell yielded an opposite result! More trials must be made and with larger numbers. It might be useful to try to keep individuals apart, for Mr. Munro Fox calls attention to an interesting fact, that when sea-urchins are ripe, a spawning male stimulates adjacent ripe individuals of both sexes so that they also spawn. A spawning female also stimulates ripe males to spawn. This simultaneous spawning makes the fertilisation of the liberated ova more certain. Similar facts have been noted for one of the Nereid worms; so they may apply to the Palolos.

LEECHES

Related, but not very closely, to the Ringed Worms are the likewise ringed Leeches. They have no bristles except in one case, but they have very effective suckers.

While there is a great variety in their habitats—land-leeches, tree-leeches, and sea-leeches—the majority live in ponds and rivers.

The medicinal leech (*Hirudo medicinalis*) shares its name with the physician who used to carry it about so faithfully and rely on it so much. Where we would say, " Send for the doctor," our forefathers said, " Send for the leech." The animal owes its virtue to the neatness of the three-rayed cut

which it makes in the patient's skin. There are three semicircular saws in the mouth, each bearing about ninety teeth, and the wound remains open as long as the leech continues sucking. In natural conditions the leech feeds on the blood of fish and frog, with which it fills ten capacious pockets on each side of its food-canal. It is said that a good meal of this highly nutritive fluid can keep a leech going for many months, and it is a very interesting detail that, as the blood is sucked in, it is subjected to the action of a secretion which prevents coagulation. The common horse-leech (Hæmopis) of ponds has not got such finely developed jaws and teeth as the medicinal leech ; it has only two pouches ; it cannot contract itself into a plump olive-shaped form ; it does not suck blood, but swallows worms and aquatic larvæ. It often makes a burrow in marshy ground when the autumn comes, and, doubling itself ventrally, passes into a lethargic state. As many as sixteen have been found together under one stone in a marsh.

The brook-leeches usually lay their eggs separately on stones or water-plants, and, brooding over them, get them fixed on the underside of the body, where they hatch. The young are exquisitely sensitive to the touch of the body of their kin, and return to shelter (not necessarily their proper parent's) even after they have begun to make excursions on their own account. Like all other members of the class, these brook-leeches (Glossiphonia and the like) are hermaphrodites, the two sexes being combined in one, as is also the case with earthworms and snails and many other humble animals. They are cross-fertilising all the same, not like liver-flukes and tapeworms which fertilise their own eggs.

On a different line altogether are the fish-leeches, which have no jaws nor red blood, but a protrusible proboscis. Very well known is the skate-sucker, Pontobdella, covered with green warts. It is sometimes seen holding itself horizontally taut against a rock that goes down into deep water, and suddenly launching itself on to a passing fish. In an aquarium these skate-suckers usually remain sluggishly in the mud, but when a piece of skate is dropped in they are instantaneously on the qui vive ; they have it—or one of

them has it—before it reaches the bottom. Exquisite sensitiveness to different kinds of external stimuli—luminous, odorous, chemical, and so on—is very characteristic of leeches when they are hungry; but gorged individuals are as markedly unresponsive. It is the same skate-leech that lays its velvety eggs in the shelter of an empty bivalve shell, and mounts guard over them for many weeks—keeping them clear of mud and the like. This prolonged parental care at a low level in the animal kingdom is very interesting; it is an other-regarding activity; it is of no apparent use to the individual. Easy enough is it to say that this parental-care habit has become hereditarily engrained or instinctive; but one wishes to know how habits involving the expenditure of energy along lines far from being those of least resistance or self-preservation have been established, and have kept agoing with such imperative force. What can one say but what Darwin said, that in the struggle for existence, which includes all answers back to surrounding difficulties and limitations, success in leaving progeny pays as well as success in filling the mouth or keeping the skin whole? What one must not think, however, is that animals deliberately run their individual lives on "sound business principles." Their "principles" are enregistered in their constitution.

Travellers tell us of losing their way in a tropical jungle and hearing in the silence a steady drip-drip all around—a shower of land-leeches. They are only an inch or so in length, and no thicker than a coarse knitting-needle; but there are hundreds of them—all hungry. When the traveller is delayed they overtake him, with a graceful, but gruesome, looping movement, as if they made leap-frog of themselves. We read in the *Cambridge Natural History* that "a whole battalion of English soldiers decamped on one occasion from a wood which was overflowing with land-leeches." There seems to be something poisonous in their bite. In Egypt long ago Napoleon's soldiers were troubled by slender water-leeches which fastened at the back of the mouth, and Sir Sidney F. Harmer, of the British Museum, has suggested that Gideon's sifting of his soldiers by distinguishing those who knelt to drink the water directly from those who used the

which it makes in the patient's skin. There are three semicircular saws in the mouth, each bearing about ninety teeth, and the wound remains open as long as the leech continues sucking. In natural conditions the leech feeds on the blood of fish and frog, with which it fills ten capacious pockets on each side of its food-canal. It is said that a good meal of this highly nutritive fluid can keep a leech going for many months, and it is a very interesting detail that, as the blood is sucked in, it is subjected to the action of a secretion which prevents coagulation. The common horse-leech (Hæmopis) of ponds has not got such finely developed jaws and teeth as the medicinal leech ; it has only two pouches ; it cannot contract itself into a plump olive-shaped form ; it does not suck blood, but swallows worms and aquatic larvæ. It often makes a burrow in marshy ground when the autumn comes, and, doubling itself ventrally, passes into a lethargic state. As many as sixteen have been found together under one stone in a marsh.

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cupped hand to lift the water to the mouth may have had reference to the danger of becoming infected with leeches. The danger has been circumstantially illustrated in the case of soldiers in the East. The leech in question (*Limnatis nilotica*) is very slender when it lives freely; but in the back of the nasal chamber it gorges itself with blood and becomes as big as a medicinal leech—a very troublesome intruder and difficult to dislodge. The moral is not to drink in the dark.

From an allotment in Finsbury Park a friend in London sent us a large land-leech. It was a giant compared with the inch-long land-leeches of India and some other warm countries—for it attained to a length of five inches. Not that a conscientious person finds it very easy to record the dimensions of a live leech. They vary so much with the changeful taste and fancy of the specimen—now long and thin, now short and plump. This ruddy-green leech from London was probably an alien, apparently of the tribe of Trocheta; and from the bath which he was offered after his long journey he promptly fled, and hid himself in the soil. There he soon disposed of a small earthworm, swallowing it whole, which is another of the ways of Trocheta. After three days, in spite of unremitting hospitality in the form of baths, varied soil, diverse temperatures, and plenty of earthworms, the interesting alien died. It seemed to be closely allied to, if not identical with, Dutrochet's Leech (*Trocheta subviridis*), which has been recorded not a few times from London and the suburbs, and farther afield. It is known in France, Italy, and Algiers. It is said to enjoy foul streams; it explores gardens and parks; its jawplates are rudimentary; it swallows small earthworms whole, and they form its staple food.

Around leeches some quaint lore has gathered like moss on a stone. Thus, Burton speaks of horse-leeches being much used to drive away melancholy, and the old books give recipes like this: "Take horse-leeches and burn them to powder, and mix with eyesel; then use to rub the place therewith where you would have the hair grow no more, and there will no hair grow on that place." Leeches were

once used almost as widely as blood-letting, but their day is almost over; and the physicians of to-day have almost forgotten the creatures which, if they did not actually give their name to the profession (Dryden, for instance, wrote "wise Leeches will not vain receipts obtrude"), came, by some etymological twist or other, to share it. But if leech-lore and leech-craft have passed away, natural history remains, and that of leeches is far from being a finished book. The number of interesting "ken speckle" forms is large. We recall Branchellion on the Torpedo with eleven leaf-like gills on each side of its body; its relative Ozobranchus on a river-turtle of the Yang-tse-Kiang; the Lophobdella of the crocodile's lips which the "Ziczac" Courser Bird, the Trochilos of Herodotus, cleans off; the Chilian burrowing leech (Macrobdella), which may be over a foot long; the still larger red leech (two feet long!) which Pennant described as always falling off the Basking Shark when that huge fish is brought to the surface; the deep-water Ancyrobdella, from Lake Biwa, in Japan, which has three grappling hooks directed obliquely backwards at the end of a long proboscis; and rare marine leeches from the angler-fish and the dragonet which seem to be in process of sinking down to the level of stationary parasites.

And not only are there many imperfectly known forms, there are many imperfectly understood facts. We smile at the observation of the old physician Mercurialis, who stated that the medicinal leech made so small a hole in man's skin that only the thinner part of the blood passed out; but we are far from being done with the study of the leech's secretion called "hirudin" which keeps the blood from clotting, and is used for this purpose in some physiological experiments. We smile at the old recommendation to one who had swallowed a leech that he should get into a hot bath, yet keep cold water in his mouth, since the leech would be attracted thereto; but we are far from being done with the sensitiveness that many leeches show to distant stimuli—a shadow over the aquarium, disturbances of the water (as Wordsworth described), and the approach of suitable food. There is still much to be learned concerning leeches.

HORSE-HAIR WORMS

Among the " worms " we must also rank the " horse-hair worms " that we sometimes find in little pools in the overflow water of a roadside stream. Old-fashioned natural history books give recipes for the production of these horse-hair worms. The simplest of these is to put some black hairs from a horse's tail into a sheltered pool in a stream, making a little rampart of stones so that they cannot be floated away. After many days they will be found writhing and wriggling about—living horse-hair worms. These worms are in some ways quite well known ; they are distant relatives of the common threadworms or round-worms (*Nematodes*); they are cylindrical, often six inches long, like thick horse-hairs, varying in colour from greyish to black. Many of them bear the name of Gordius, and a considerable number may be found together, tied up in a knot difficult to unloose—a Gordian knot.

One Saturday, fifty years ago, four schoolboys put some black horse-hairs in a pool in a tiny stream. Not that they had read the old recipe ; it was just a country tradition, like many others almost swept away now. Some weeks afterwards, when the boys remembered their experiment in the midst of many urgent affairs, they went back to the pool and found wriggling black worms as living as living could be. There was no one to explain the mystery. Another day they found an interesting pool in a streamlet that ran right across a by-road (the place was called Hermiston)—interesting because it was so crowded with black horse-hair worms that one of the boys lifted a handful of over two dozen — we feel them wriggling still—and that was not nearly all. Surely it must have been a big horse — a Pegasus, perhaps—that dropped so many hairs from its tail !

Modern research has cleared up a great part of the mystery of the horse-hair worms. The long living threads *creep out of insects*, especially out of crickets and grasshoppers and beetles, that come to the pools for an evening bath or for some other reason. The horse-hair worms have been

living for months inside the insect's body. They absorb fluid food from their host's blood, and they absorb it, apparently, by their whole surface, for they have either no mouth at all or only a pin-prick opening insufficient to allow much in the way of nutritive juice to enter. The gullet is usually blocked.

These unpaying boarders that live in grasshoppers, beetles, and other insects, are not at first in any hurry. They feed, they grow, and they moult—a logical as well as a biological sequence. As they grow they have to cast off the non-living enveloping cuticle, for which they have become too big. But when they have reached that mysterious colon : Full Size, they become ill at ease. They dispose themselves inside their host with their head-end close to the surface, just as if they knew that this was the best attitude for creeping out quickly when the insect enters water to bathe, or comes to the water-edge to drink, or lingers to cool itself among the damp grass near the pool.

When the insect-host is in moist surroundings, which may mean water, the horse-hair worms force their way out. They wriggle to a pool, or, if they are in the water already, they proceed at once to swim about urgently. The males, which are marked by a slightly forked tail, seek for the females till they find them. After the pairing, the females twist about among the roots of half-submerged grasses and among other vegetation more thoroughly aquatic, and lay their eggs in white strings, often intertwined with the plants. A short time afterwards, the parents of both sexes begin to be sluggish ; they wilt away and die. For it often happens that starting a new generation means a full stop to the one before. Reproduction is often the beginning of death. It is very interesting to try to trace, in the great diversity of present-day animals, the various expedients that have been arrived at, age after age, to stave off the death that is apt to be the penalty of multiplying. This is a *trend of evolution* which is in progress still. The big lusty lamprey dies after spawning, but the migratory bird may journey half round the world after the fatigues of its breeding season.

In the case of the horse-hair worms, the eggs in the twisted strings develop into transparent, thread-like larvæ, and these cut themselves free by means of an anterior proboscis armed with sharp stilets. For a short time these microscopic threads swim actively in the water, but their inborn impulse is to bore into something animal. Long ago, perhaps, they may have lived, as many threadworms live, in rotting material, and only gradually came to improve upon this by boring into a living creature. For in such simple ways many forms of parasitism may have begun, and we should remember that to a horse-hair worm an insect is not an insect, but simply an inviting corner which suggests energetic boring. That this is not a perfect or finished world is revealed in the little detail, that the larval horse-hair worms sometimes bore into a host which disagrees with them more than they disagree with it, and then they die. But if they bore into an appropriate host, such as a grasshopper or a cricket, they develop into full-grown worms, which return to the water by and by. Sometimes there are complications, for the larva may enter the aquatic young of an alder-fly, or of a mayfly, or of a harlequin fly, which may be devoured by a predaceous beetle or some other hungry creature. In this second host the larval horse-hair worm continues its development.

There are said to be over a hundred different kinds of horse-hair worms, and there is no doubt some variety in the life-history. But in a general way the story is now clear. The living horse-hairs which the schoolboys found in the stream were Gordian worms. They came out of the body of an insect, in which they had spent their youth as parasites, usually troubling their host very little. After producing eggs and fertilising these, the adult horse-hair worms die; but the eggs develop into larvæ, which enter insects and grow up there. And so the story goes on. It is much more wonderful than if the horse-hair worms were the outcome of soaking horse-hairs in water. For that would be magic.

XXVI

ECHINODERMS OR PRICKLY SKINNED ANIMALS

STARFISHES, sand-stars, sea-urchins, sea-cucumbers, and feather-stars form a well-defined group of marine animals. The symmetry of the adult body tends to be *radial*, that is to say, there is no right and left side, as in *bilateral* animals. There is a strong tendency to deposit carbonate of lime, which forms an external armour of plates and spines or an internal supporting skeleton; but it must be kept in mind that bone is restricted to Vertebrates. The framework of lime is added to as life goes on, so that there is no need for moulting as there is in Crustaceans. Many Echinoderms surrender parts of their body in critical situations and are able to regrow or regenerate what they have lost. Very characteristic is the poor development of the nervous system, which is usually lacking in centres or ganglia. Also characteristic is a peculiar "water-vascular system," often used in locomotion or in respiration. In most cases the young stages are minute free-swimming larvæ, not the least like the adults, and the life-history is thus very circuitous.

STARFISHES AND THEIR RELATIVES

A fish out of water is miserable indeed, unless it be one like the mud-skipper that climbs on the rocks and mangroves on tropical shores, or like the lung-fish that lies low for half the year breathing dry air in a hole in the floor of the empty pool. But even more miserable is a starfish out of the sea. It collapses like a punctured tyre, and as the water passes out of it the life goes also. Especially in regard to such-like creatures is it true that the activity

we call life is a very watery business. It is a remarkable fact that living matter contains about 80 per cent. of water. Therefore the starfish must be studied at home in the shore-pool.

It is interesting to watch a starfish hauling itself up the face of a submerged rock. It moves by means of a hydraulic system. Water is sucked in at a perforated dorsal plate, like the rose of a watering-can ; it passes through a set of water-pipes to hundreds of suctorial tube-feet in a deep groove on the underside of each of the five arms. These tube-feet become tense, like a hose-pipe when water flows into it, and they are pressed against the rock, like so many firm fingers. Then the water flows out of them into little bladder-like reservoirs (ampullæ) arranged in rows in the inside of the arm, and the result of this is to make the starfish adhere to the rock. The fact is that a partial vacuum is formed between the tip of the tube-foot and the surface of the rock, a little like the partial vacuum which street boys make on the pavement with a leather sucker and a string. The starfish then contracts the muscles in the wall of the tube-feet, so that they become shorter. This draws the creature up to the place of its attachment, just as the shortening of a hawser draws the ship close to the side of the pier. The next step is to inject water with some force from the contractile reservoirs into the tube-feet, obliterating the partial vacuum and setting the tube-feet free. The starfish would then fall down again, were it not that meanwhile another half hundred tube-feet on another part of the arm, or on another arm altogether, have been fixed higher up. So the starfish climbs the rock—as quickly as a snail !

It often happens on the seashore that the waves dislodge a stone, which then pins down some unfortunate animal. When a heavy stone imprisons a starfish's arm, or when a sea-slug gets on to an arm and begins to secrete sulphuric acid from its mouth, why, then there is *autotomy*. This curious word, meaning self-mutilation, is the technical term for surrendering a part to save the whole. And it works very well, for the starfish that has escaped from deadly peril can regrow another arm at its leisure. Along the ventral

groove of each arm there is a strand of nerve-cells, the five strands being united in a pentagon around the mouth; and then there are scattered nerve-cells here and there. But the starfish has no brain, not even a single nerve-centre or ganglion, so that when it gives off a limb to save its life it does not know what it is doing, as we count knowledge. What happens is due to a very forceful contraction of muscles at the base of the arm, so forceful that the arm breaks off; but this is an action comparable to ours when we draw away our finger from something very hot, without willing, almost without knowing; it is a reflex action. Animals can learn without understanding, just as many people do in mastering some dexterity. They get the "hang of it," but not the idea of it. The fact remains that in the course of time the starfish has learned in its constitution, if not in its mind, that it is better that one member should perish than that the life should be lost.

Unlike most soft-mouthed or jawless animals, the starfish is a carnivore, and it is very fond of mussels and small oysters, as already described. Some starfishes will even eat the bait off the fisherman's lines. It is said that the fishermen in revenge sometimes tear the starfish they catch into five parts and throw these into the sea. But this is not a wise thing to do, for each arm may, in favourable circumstances, grow a new starfish. We often get what are called "comet" forms of starfish, where one arm is just beginning to regrow the lost four.

A starfish, as large in appetite as it is small in wits, has some resoluteness. For it will tackle a small sea-urchin in the shore-pool. It lays an arm on the hedgehog-like surface, and it gets its soft tube-feet nipped by hundreds of little stalked snapping-spines (pedicellariæ) which project among the big spines like so many minute three-bladed scissors. But when these snappers have gripped the soft tube-feet they cannot quickly let go, and when the starfish moves away its arm they are wrenched off with it. The starfish does the same with another arm, and with another, without haste or rest, till it has disarmed the sea-urchin. Here we see a brainless creature following a line which is not the line of

least resistance, and working steadily towards a distant goal. This is the threshold of *Endeavour*.

As another type of coast-animals we take the sea-urchins. Many of them have long since left the shallow water and explored the great depths. Strange prickly balls, they got their name from their resemblance to hedgehogs in the old days when it was believed that the creatures of the sea were counterparts of those on land. But the hedgehog and the sea-urchin—Mammal and Echinoderm—are as far apart as two animals could well be. They agree only in their prickliness.

At the south pole of this living globe there is a small mouth through which five strong teeth project. Around this there are ten large tube-feet used in tasting the food. Farther out there is a broad, soft circle bearing many spines, and where this joins the hard shell there are ten branched gills, only visible when the animal is in good condition and in the water. At the north pole of the globe there is a complicated apical disc, best studied by rubbing the spines off a dead sea-urchin. The food-canal ends in the middle; around this are five plates, through apertures in which the germ-cells are shed into the sea; between these are five smaller plates through which a sensitive tentacle-like tube-foot is protruded. One of the five inner plates is larger than the other four, and is covered like the rose of a watering-can with minute pores, through which water is ceaselessly wafted in to work the hydraulic system of water-tubes used in locomotion and also in respiration.

Now, to cut a long story short, there extend from the "north pole" to the "south pole" five broad meridians bearing spines, and five narrow meridians bearing not only spines but locomotor tube-feet. As the sea-urchin grows, new plates are added round the circumference of the apical disc; but each plate can also be added to by the adjacent living tissue.

There are three ways in which a sea-urchin moves. It uses its spines like stilts, which can be swayed in any direction. Like a starfish, it uses its tube-feet for climbing up the rock, attaching them, shortening them, releasing them after fixing

others. But on a level stretch of firm mud the sea-urchin protrudes its five teeth and hobbles along on their tips, tumbling a little from side to side. The curious mechanism should be studied by breaking open a dead sea-urchin. It is called Aristotle's lantern, for he saw it more than two thousand years ago. Besides levering the animal along, it is a chewing apparatus, crunching up seaweed and small animals, and it also helps in breathing. In the golden-yellow heart-shaped sea-urchin which burrows in the sand, the spines are the only locomotor structures: the tube-feet are used for collecting microscopic organisms, which are transferred to other tube-feet round the mouth, and pushed by them into the food-canal.

Talking of movement reminds us of the numerous glassy spheres of lime which may be seen on the sea-urchin's shell among the spines. When the animal is moving on a slope the heavy heads of these transformed spines droop towards the lower side, and they thus serve to give the animal information in regard to its position. In other words, they are balancing organs, with a function somewhat like that of certain "gravity sacs" in connection with our ears which enable us quite automatically to keep our erect posture in running.

When we watch a sea-urchin in a basin of water, we see a great activity all over its surface. The spines sway on their ball-and-socket joints; the translucent tube-feet search about for some support; and among the spines there are minute snapping-blades or pedicellariæ, mounted on stalks. Some of these snapping-blades give poisonous bites, and one bite has been known to make a frog's heart stop beating. Others catch and kill minute creatures which might anchor on the sea-urchin's shell; others capture small animals which the tube-feet afterwards pass to the mouth; and others again seize a particle of grit with two of the blades and hammer it into powder with strokes of the third.

There is quite a bustle of activity all over the sea-urchin, and we know that the whole of the delicate, transparent, tissue-paper-like skin is covered with microscopic cilia

which are always waving, just like those in our air-passages. Each snapping-blade can act on its own, and each spine likewise, for the sea-urchin has no brain in the ordinary acceptation of the term. The movements of the snapping-blades and spines are "reflex actions," taking place automatically like our coughing when a crumb threatens "to go down the wrong way." There are so many of these automatic reflexes in a sea-urchin that the animal has been called "a republic of reflexes," and the wonder is that the multitudinous movements of spines and snappers and tube-feet work out so harmoniously.

There is a loose network of nerve-cells and fibres beneath the skin, by which news can be passed from one part of the animal to the other. There is also a nerve-ring round the mouth and a branch running up each of the five areas through which the suctorial tube-feet are protruded; but though this helps to make the different sections of the body work in unison, it cannot be called a controlling centre. "In a dog the animal moves its legs; in a sea-urchin the legs move the animal."

Sometimes a gull lifts a sea-urchin from among the low-tide seaweeds and lets it fall from a height so that the shell is broken. Sometimes a starfish disarms a small sea-urchin and smothers it by protruding its elastic stomach. There are other dangers, but is there any animal less vulnerable? The fact is that the sea-urchin's struggle for existence is mostly in its early youth, which is spent as a free-swimming pinhead larva in the open sea, away from the rough-and-tumble life of the shore. There are immense numbers of these delicate, transparent larvæ—each like an inverted easel with many legs—and there is great mortality among them, for they form part of the edible dust of the sea. One of the triumphs of recent zoology is Dr. Isabella Gordon's story of the development of the sea-urchin's elaborate shell, starting with a few three-rayed spicules in the free-swimming larva.

XXVII

STINGING ANIMALS AND SPONGES

THERE is no common name that will include Jellyfishes, Sea-Anemones, Corals, and Zoophytes, but they may perhaps be called " Stinging Animals," since their skin almost always bears numerous stinging cells. The technical name of the group is Cœlentera—a difficult term which means that the cavity of the body is the food-canal.

In the great majority the symmetry of the body is radial, that is to say like a cylindrical vessel. Until one looks into details it is plain that the body of a jellyfish or a sea-anemone could be cut into perfect halves along many different lines, whereas there is only one way of halving a bilateral animal like an earthworm, a beetle, or a sheep.

Most Stinging Animals have tentacles. The food-canal ends blindly. There is a great tendency to form buds and thus to build up colonies. Many sedentary forms become coralline.

The group includes a great variety, *e.g.*, Jellyfishes or Medusæ ; Sea-anemones and related Corals ; Alcyonarians and related Corals ; Sea-pens or Pennatulids ; Hydroid colonies or Zoophytes, many of which bud off free sexual " Swimming-Bells " or Medusoids. Highest of all are the Sea-gooseberries or Ctenophores ; lowest of all are the freshwater Polyps.

SEA-ANEMONES

Very common on all rocky shores are the Sea-anemones. When the tide is out they close up, and appear to be merely rounded blobs of glistening, pulpy flesh, a little like small, soft figs ; the commonest are dark brown and deep red. But when the tide comes in, they open out, as we may sometimes see in a rock-pool. They unfold themselves,

as a flower is unfolded when the bud opens ; but instead of having petals, they are fringed with a circle of short, thin-walled tentacles, which surround the mouth. They are able to move about by creeping on the rock to which they cling, but instead of hunting as the crab and the octopus and the starfish do, they prefer to remain still and wait for some victim to come their way. Their tentacles are armed with stinging cells, not strong enough to hurt our hands, but able to catch and paralyse any small animal. Little crabs and shrimps, little fishes, or any scraps of flesh in the water, which chance to brush against the tentacles, are caught and pushed inwards to the mouth and swallowed. In doing this the tentacles act automatically, like a dog that scratches itself in its sleep ; and, therefore, it is quite easy to cheat them, with a little stone or bit of paper, which they will grasp just as eagerly as though it was good to eat. But it is very interesting to find that we cannot go on cheating one anemone for long ; after a little, it will refuse to take any notice of our deceptive baits ; we have tried to cheat it once too often. Now the anemone is an exceedingly simple animal, much simpler even than the starfish : it is circular, it has no front or back, nor right and left : it cannot be divided into body and head : it has nothing at all that can be called a brain. Yet, as we have seen, it can do things that are not merely automatic : it can learn a lesson, and remember it for some time.

When the tide goes out, or when it is disturbed or interfered with, the common red anemone shuts itself up ; it contracts into a shapeless blob of jelly-like flesh ; and so do many of its relatives. But there is one, quite common on the southern and western coasts of England, which does not do this. Its body is dull brown, and its tentacles are long, slender, and very numerous ; they may be brown, or buff, or ashy grey, or green with reddish tips ; and they are not tucked out of sight when the creature is disturbed. In some places, at least, this anemone has entered into a strange sort of alliance or partnership with a peculiar crab. This, the Long-legged Spider-crab, as it is called, is very unlike the common Shore-crab in its ways. It has a small triangular

body the size of a halfpenny, its claws are not very strong, but its legs are exceedingly long and slender, so that the full reach from tip to tip is from four to six inches. One might imagine that an animal with such long legs was built for speed, but as a matter of fact the Spider-crab is excessively leisurely in all his movements. Each step forward seems to require a slow hoist upwards, a sort of lurch forwards, and a gentle settling down, followed by a pause for reflection before the next stride.

This Spider-crab, like some of its relatives, has a way of decorating itself with bits of seaweed and so forth, so that it becomes difficult to detect; but besides this, it at times takes shelter in the shadow of the long, snake-like tentacles of the anemone of which we have spoken. Here, of course, it is not merely hidden but defended by the anemone, which in turn appears to make no effort to capture and eat the unbidden guest.

Sometimes a scrap of flesh chances to fall on the floor of the rock-pool, just beyond the reach of the anemone's tentacles. Then the crab, like the giant in the story, becomes aware that there is something to eat not far off; and it sets off on a voyage of discovery, which eventually ends in its finding the prize—the stray crumb from the table of some untidy feeder—fish, crab, or lobster. Now the first thing the Spider-crab does is, not to eat up its booty, but to drag it back to the protecting shelter of the anemone, for greater safety. But in a moment one of the tentacles of the anemone brushes against the crab's prize, and at once it is captured and pulled from the crab's uncertain grasp, and swallowed; leaving the crab, with every appearance of bewilderment, to resume in vain its anxious searchings of the neighbourhood. But the crab gets its turn at last, many hours later, when the anemone has quite done with the scrap of flesh; almost the whole has been digested, leaving only a thin white film, which the anemone forces out of its mouth. Once again the crab starts to search, with as much appearance of energy as it ever displays; and in the end it will find, and eagerly devour, the white film that the anemone has found no use for.

JELLYFISHES

There are no more beautiful marine animals than jellyfishes, but to appreciate their beauty one must see them swimming. The disc pulsates rhythmically; the tentacles and frilled lips float out behind with graceful, twisting movements; the translucent colours—such as blue, violet, red, and orange—are often very fine. When jellyfishes are stranded on the flat beach, they have lost most of their charm, and those preserved in museums are seldom attractive. In spite of their name, Medusæ, which refers to the snaky tresses and suggests something terrifyingly Gorgon-like, jellyfishes are extraordinarily decorative.

The great majority of jellyfishes are *pelagic*, that is to say, they frequent the surface waters of the open sea, but a few have colonised the abysses, and some live near the bottom in shallow water. There is an unusual kind called Cassiopeia, common in harbours in the East Indies, that lies *on its back* on the sea-floor, remaining for hours or days at one place. It has a very stiff bell, which in some species bears a sucker-like dimple where it touches the ground. The concave surface of the bell is turned upwards, and instead of a proper mouth there are numerous pinholes on the eight or more branched and frilled lips. As these lips are often greenish or reddish, they are suggestive of seaweeds. But we do not dare to say that this resemblance is of any use.

Our commonest jellyfish, *Aurelia aurita*, of a blue-violet colour, is often about the size of a soup-plate, but it is small compared with many. Thus the amber-coloured Cyanea, sometimes so common that it breaks down stretches of salmon stake-nets in the shallow water along the shore, often has a disc a yard in diameter—quite big enough for a mermaid to sit on. The tentacles float out behind for a distance of many yards, and they are to be avoided by bathers, since their myriads of stinging threads are strong enough to pierce the human skin. The beautiful blue "corn-flower jellyfish," *Cyanea lamarcki*, is perhaps just a colour variety of the amber-coloured "hair-jellyfish," *Cyanea capillata*, but it never grows so large. On the other

hand, an Arctic variety or species, *Cyanea arctica*, must be the longest of all backboneless animals, for one has been measured with a disc seven and a half feet in diameter and tentacles 120 feet long ! It is plain that the only possible home for such an animal is the open sea, where its huge bulk is supported buoyantly and where there is nothing to knock against. We may notice here that one of these enormous jellyfishes, with its tentacles swaying in the water, might readily form the basis for a sea-serpent story.

All jellyfishes are carnivorous. They depend a good deal on small open-sea crustaceans, which are present in inexhaustible abundance, but some devour the floating eggs of fishes and also the fry. Many feed greedily on smaller medusæ, and also on swimming-bells or medusoids, which are not nearly related. There is undoubtedly a wide range of possible food, including, in the case of the mouthless Rhizostomes already mentioned, very minute organisms. It is of interest to notice that the largest jellyfishes are those of the cold seas, a fact to be connected with the increasing abundance of minute surface creatures as we get farther away from the Equator. One reason for this seems to be that life is less intense, more drawn out, in the colder waters, and thus more generations are represented simultaneously. Hence our northern fisheries, for they depend in the long run on the abundant supply of very small open-sea organisms.

When a jellyfish is rigorously starved it is able to live for a month or six weeks on its own jelly. Though most of the jelly is water, there is a small percentage of something organic, allied in composition to gristle or to chitin, and that something keeps life agoing. Of course the creature must get lighter and lighter every day, and this happens according to a very regular law—that the loss of weight each day is proportional to the weight of the animal at the beginning of that day. Thus the less jelly there is the longer it lasts !

This seems an appropriate moment for noting that the Japanese eat jellyfishes—a dainty kind of repast. They take a kind of medusa called Rhopilema, and cure it with alum and salt, or between leaves of a sort of oak. Before being

placed on the table the dried jellyfish is soaked in water, cut into strips, and flavoured according to taste. What chances we miss!

In capturing their prey, jellyfishes are helped by the countless stinging-cells on the tentacles and lips. When one of these cells is touched by an appropriate stimulus it explodes and jerks out a long lasso, which can often penetrate the victim's skin. The function of these "nettle-threads" is partly grappling and partly paralysing. According to some authorities the poison is formic acid, but the effects in certain cases suggest something more subtle. An interesting point is that a medusa may kill a fish of considerable size, and yet other fishes much smaller may enjoy immunity. They swim about under the shelter of the umbrella, in and out among the tentacles. Thus young whitings are often guests of the amber "hair jellyfish," and a hundred horse-mackerel may hide under a Rhizostome. The common companions are to be distinguished from predatory little fishes that nibble off pieces of the medusa, and often get caught in so doing. The stinging is sometimes virulent, and the members of the Charybdeid family are popularly called "sea-wasps." They swim with unusual vigour and capture fishes inconveniently large for their stomachs. In our yellowish or bluish Rhizostome, which may have a disc-diameter of a foot and a half to two feet, a shelter is given to small Amphipod crustaceans as well as to fishes. Here we may notice that besides the cosmopolitan Aurelia, which is found from pole to pole, the amber and blue Cyanea, the yellowish or bluish Rhizostome, there is another readily recognisable jellyfish in British waters, the Compass Medusa or Chrysaora. It occurs in a variety of colours, especially reddish-brown, and owes its popular name to sixteen radiating lines which split into thirty-two about half-way across the disc. It is peculiar in being male and female at once, or male when it is young and female when it grows older, for the rule among jellyfishes is to have separate sexes.

The fertilised eggs of the jellyfish are sheltered for a time in the niches of the frilled lips; in typical cases they become

free-swimming ciliated embryos, which soon settle down on rocks as fixed polyps. By a strange transverse budding the polyp or hydra-tuba forms " a pile of saucers," and one saucer after another tumbles off, growing rapidly into a perfect jellyfish. Thus the typical life-history of a jellyfish exhibits what is called alternation of generations.

How beautiful the mode of swimming—by increasing the curvature of the umbrella and driving out a mass of water. Dr. A. G. Mayer says that sodium oxalate forms as a waste product in the pinhead sense-organs round the margin, that calcium chloride in the sea-water soaks in and precipitates calcium oxalate, setting free sodium chloride (common salt), which is a powerful stimulant for the nerve cells, causing them to command the muscles on the under-side of the bell to contract. How very interesting are the sense-organs, which we see so clearly in eight niches on the margin of Aurelia. Each is just a speck, but each includes a part sensitive to light-waves, a part sensitive to chemicals in the water, and, thirdly, a balancing organ. If the sense-organs are injured the jellyfish is no longer able to swim rightly.

CORALS IN GENERAL

Judged in regard to their beauty, corals rank high, but, for animals, they have not many habits. It is difficult to believe that they are quite awake; they seem to be dreaming, and their beauty reminds one of the smiles of a child asleep. There always seems a contradiction in terms in *sedentary* animals: it is a surrender of the birthright of locomotion, though they usually insist on asserting this in their earliest stages. Yet no one can say that corals have lost any beauty in becoming fixed. In their architecture, and even in the stones or spicules with which many of them build, they are exquisitely beautiful, and the same is often true of their colouring when alive, and of the branching of those that form colonies.

We recently obtained for identification a sea-anemone-like solitary cup-coral which the *Michael Sars* Expedition had dredged from a depth of about three miles in the North

Atlantic. We boiled away the brownish flesh and disclosed what angels might desire to look into. It is not much bigger than an egg-cup, but it is like a king's crown dimpled in. Pure glistening white, it might be a rose-bowl for the Queen of the Fairies. We keep it in a jewel-box and look at it on feast-days. We refuse to think of the time when it must go back to Norway with a label. There is no doing justice to the beauty of these things, and there are scores of them, born to blush unseen in the deep sea. They are superlatively beautiful, that is all one can say. They are organic dream-smiles.

There is no class or group of "corals," for the word is simply a convenient name for those kinds of Stinging Animals (or Cœlentera) that form very hard, substantial skeletons, usually of carbonate of lime. Perhaps it may be useful to take a survey of "corals." (See Professor S. J. Hickson's fine book on *Corals* (1925).)

Sea-anemones, as every one knows, are soft-bodied, cylindrical animals with stinging tentacles encircling the mouth and with a basal disc usually attached to a rock. Nearly related to these sea-anemones are the solitary cup-corals, where the skin of the animal forms a shell of lime. For the word "shell" is at least as appropriate as the word "skeleton." As the wall of the cup is gradually added to and rises, the skin of the animal may fold over it, and internal partitions of lime are formed, radiating from the wall of the cup to the centre, where they sometimes unite in a pillar. But as the partitions or septa rise, pushing their way, as it were, into the body of the coral-polyp, the fleshy tissues retreat before them, so that, in spite of appearances, the coral skeleton is always *external* to the living animal. Our own skeleton is obviously inside our muscles, and it is alive; the cup-coral's skeleton is outside, though it may not seem so, and it is quite devoid of life. It is added to, but it does not grow. The cells that contribute the stones and mortar to the coral edifice die in so doing. No doubt the lime comes from the sea-water, but carbonate of lime is a scarce salt in solution in the sea as compared with calcium sulphate, and there is much to be said for the theory that ammonium-

carbonate, formed as a waste product in the marine animal, undergoes "double decomposition" with calcium sulphate from the sea-water, yielding ammonium sulphate, which passes out in solution, and calcium carbonate, which forms the coral's "castle of indolence."

From a solitary cup-coral there is a gradual transition to the reef-building corals or Madrepores, which are great colonies of individuals. They arise by the budding and division of polyps, and the crowding often becomes so intense that individuals merge. Thus in a big block of brain-coral, so-called from its suggestion of the convolutions of a mammal's brain, it is impossible to tell on the cleaned skeleton where one individual ended and another began. When the coral is living one can, of course, distinguish and count the individual mouths with their wreaths of tentacles. Such a colonial coral is sometimes beautifully arborescent, so that individuals of many different ages may be flourishing together; but in most cases the new generations grow on the shoulders of the old and smother them. Thus the greater part of a coral colony is a cemetery. By filching lime from the sea these reef-building Madrepore corals have added greatly to the solid earth. The Great Barrier Reef of Australia stretches for over a thousand miles!

Next to the Madrepore corals, but utterly unlike them, are the black corals or Antipatharians. They are most abundant in the warmer seas, but British trawlers bring in large colonies from northern waters, such as off the Faroe Islands. We sympathise with the fishermen in their protest that their captures are plants, for some of them are like dwarfed Japanese trees, and others suggest the stems of some climbing plant like honeysuckle. But close scrutiny shows a crowded multitude of small polyps, usually with six simple tentacles, and forming in their midst a black horny axis covered with prickles like a branch of briar. In old colonies this axis may be thicker than one's thumb and as hard and black as ebony. It takes on a beautiful polish, but it is hard stuff to carve.

If one suddenly says "coral" to a lady, she thinks at once of beads or babies, whereas a man thinks of coral

islands and either of Ballantyne or of Darwin, according to his upbringing. The beads and the baby's amulets are carved from the axis of the Precious Coral, *Corallium rubrum*, which is fished in Mediterranean and in Japanese waters. It has white polyps embedded in red flesh, and in the centre there is the coral-red axis, always being added to in some mysterious way, perhaps implying a rapid solution of the lime, followed by an equally rapid hardening. The red flesh connecting the polyps by an intricate system of canals owes its redness to the presence of innumerable red spicules of microscopic size and rather ornate shape. Now it is from some kind of coalescence of these quite separate spicules that the solid central axis is formed. There is the same difficulty in the case of the Organ Pipe Coral, *Tubipora musica*, whose finely coloured tubelets are threaded into necklaces for children. Each polyp, mostly white in colour, lives in a red tube of lime, and the scores of tubes are bound together like a set of organ-pipes. On the polyp, where it puts its head out, we can just see little rings of separate red spicules. In a short time a group of these will be added on to the upper rim of the hard tube, but how it is done we do not know. We fancy that there must be a rapid solution and then a rapid reprecipitation in another form. Corals like the "Precious" and the "Organ Pipe" are called Alcyonarians, and are near relatives of Sea-fans and Sea-pens and Dead Men's Fingers, as also of the rare Blue Coral (Heliopora), which is the only living representative of an extinct race of great antiquity. And here we may mention that of the ancient Rugose Corals that are exceedingly common as fossils there are no living representatives at all. One race cometh and another goeth. All things flow, as Heraclitus said, even corals.

This survey has its use in showing that the word "coral" is a physiological term, indicating a habit of life, for we have seen that it includes, among living types, the Madrepores, the Antipatharians, and the Alcyonarians, which are not nearly related to one another. Coral means a sedentary Stinging Animal, given to making a hard skeleton, usually of lime. To those we have mentioned must be added two

other orders, the Millepores and the Stylasterids. These belong to a different class altogether—the Hydroid zoophytes—and it must be interesting to see a minute swimming-bell or medusoid issuing forth from a stony Millepore, for there is alternation of generations here just as in many of our common zoophytes. But this is certainly another story.

THE FRESHWATER HYDRA

Every observer of pond life is familiar, more or less, with the hydra, or freshwater polyp, which is found everywhere in clean pools, hanging on to aquatic plants. It is a small tubular animal, a quarter to half of an inch in length, and as narrow as a needle. There are green, brown, and greyish species. It has a crown of six to ten hollow tentacles around the mouth, and it usually hangs head downwards from the water-weed. In many cases it is attached to the under surface of the tiny green shoots of the duckweed (Lemna), which is the second smallest flowering plant in Britain. Indeed, very few people have seen its flowers. With its tentacles the Hydra stings and lassoes small animals, such as water-fleas, and these tentacles may be elongated till they are three or four times longer than the tubular body. But when the water is disturbed the tentacles contract to minute knobs, and the Hydra cowers against the water-plant till it is very inconspicuous indeed. The green species is of course more difficult to detect than the brown one or the grey one. When the duckweed is put into a glass vessel, preferably with flat sides, the Hydras usually take up their position so as to get most light. It is quite easy to prove that the polyps can shift from one side of the vessel to another, but if things are going well they remain for a long time attached to the same spot. One can see them swaying gently in the water, and watch the elongation and retraction of the thread-like tentacles. The Hydra is a very simple animal, but it is full of interest.

The Hydra was discovered during one of the intensely active periods in the history of zoology, when the introduction of the miscroscope opened up a new world. Not only

was there a disclosure of an unexpected and fascinating intricacy in the structure of such animals as insects, but a large number of new creatures came to be known. One of these was Hydra, and its date was 1702, when that extraordinary observer Leeuwenhoek described it to the Royal Society of London. He was also the first to speak of Bacteria and to make a microscopic study of yeast! Of the Hydra he says quaintly that its tentacles, seen under the microscope, seemed to be several fathoms long; but more important was his statement that the polyp formed buds which are set adrift. He also saw a little parasitic Infusorian swimming about on the surface of the Hydra, just as we see it to-day. The Hydra must have got accustomed to it, for it does not excite the stinging lassoes.

But while Leeuwenhoek was the first naturalist to see the Hydra, its real discoverer was Abraham Trembley (1700–1784), and before us as we write we have his charming book, with beautiful type and illustrations—*Mémoires pour servir à l'histoire d'une genre de polypes d'eau douce.* Trembley was a Genevese, who in 1740 was acting as tutor to the two boys of the Hon. William Bentinck, English Resident at The Hague. In the ponds round Bentinck's country house at Sorgvliet, a mile from The Hague, Trembley used to fish for water insects, and in so doing he found Hydra. He thought at first that it must be a kind of water-plant, with a mobile flower. He knew about the Sensitive Plant, and thought his small captives might be somewhat similar. But when he saw the Hydra move from place to place in his glass vessel he was inclined to conclude that it was an animal. Yet when he cut the Hydra into two parts, and had the pleasure of seeing the posterior half grow a new set of tentacles, he swung back to the view that it must be a plant. At another time he saw the Hydra devouring small water-fleas, and that made him think it was an animal. Yet again he saw one budding and that made him return to the idea that it was a plant. Moreover, some of his puzzles were green and others brown. Another day he saw the Hydra liberate an egg-cell or ovum! Little wonder that Trembley oscillated between regarding Hydra as an animal and

regarding it as a plant. Or could it be some strange "betwixt-and-between" living creature? In his hesitation Trembley sent some specimens to Réaumur, almost equally famous as physicist and naturalist, who at once declared them to be animals, and proposed the name polyps, originally applied to cuttlefishes. It was Linnæus who afterwards suggested the name Hydra, which recalls the mythical monster with which Hercules contended. When Hercules slashed off a head another one sprouted out, and that is what the little freshwater polyp does. If one is cut up into several pieces, each piece may in favourable conditions grow into a complete Hydra. But the piece must not be too small —there is a *quantitative* limit to "regeneration"; and it must contain a sample of all the different kinds of cells in the body—there is a *qualitative* limit as well.

Nowadays we do not hesitate as Trembley did in regard to the animal nature of Hydra, for the essential differences between plants and animals are now understood more clearly. Hydra feeds like an animal; it has animal cells; it develops like an animal; and so on. It belongs to the great series of Stinging Animals or Cœlentera, including zoophytes and swimming-bells, sea-anemones, and jelly-fishes; but, like a few others, it has wandered from the old home in the sea and become a tenant of freshwaters. Trembley would probably have been rather staggered if he had been told that his green polyps were dual organisms, for it is generally believed nowadays that the minute greenish corpuscles in the inner layer cells of the green Hydra are partner Algæ, which conduce to the animal's well-being by liberating oxygen and building up carbohydrates. If a green Hydra liberates an egg while kept in the dark, that egg develops into a white Hydra, which is supposed to mean that the partner Algæ do not migrate into the egg when there is no light.

Trembley did not know of the Hydra's numerous stinging cells which penetrate into and benumb small animals, but he noticed that fishes and whirligig-beetles reject the Hydra after once biting it. He tells us that the favourite food of his captives was the minute crustacean called Daphnia, but he

also reports meals of minute worms and insect-larvæ. He describes one of the ways in which the Hydra moves about, looping along by alternately fixing the fore and hind ends of the body; and he figures a single tentacle suspending the polyp to the surface film! He tells how he cut a Hydra into four longitudinal strips—a triumph of manipulative skill—and got a perfect animal from each. He was also one of the first animal grafters, for he re-united cut-off pieces and got extraordinary monstrosities—such as seven-headed Hydras. One of the vignettes in his book, shows him turning a Hydra outside in. With a bristle he pushed the base inwards until it came out at the mouth. As the polyps may continue to flourish after this drastic operation, some explanation is necessary, for it means turning the digestive surface to the outside. The view of those naturalists—not many—who have succeeded in repeating Trembley's neat experiment is, that if you can turn a Hydra outside in, it turns itself inside out when you are not looking, and thus restores the original condition. And if the Hydra be spitted on a bristle so that the self-righting is impossible, what happens is that the in-turned outer layer disintegrates, but a new growth from the mouth region spreads over the out-turned inner layer and covers it up. The interest of this is that the outer layer, or ectoderm, cannot change into inner layer or endoderm, or conversely. Each layer has its own character, which cannot be radically altered.

Perhaps it may be thought that we have spoken in a somewhat callous way of cutting the Hydra into strips and so on. But it must be noted that there can be no question of cruelty or pain when we are dealing with an animal whose nervous system is as simple as Hydra's. For all that Hydra shows in that direction is a sprinkling of superficial sensory cells connected by fine fibres with a network of ganglion cells. Moreover, if Trembley's Hydra could be described as in any way happy, was it not multiplying happiness to cut it into four strips which grew into complete animals?

There are many very interesting facts in regard to Hydra, such as its two kinds of digestion (intra-cellular and extra-cellular), its profuse budding when there is abundant food

in a genial temperature, and its liberation of these buds when a check comes, its production of a single egg at a time, and its occasional ability to fertilise its own egg.

Hydra is such a simple creature, with so much power of re-growing, that one would expect to find that it had a long life. It looks like the kind of animal that could continually recuperate itself from the effects of wear and tear, and thus avoid ageing. But the facts are rather against this. In an aquarium, at any rate, the Hydras are periodically subject to what is called "depression." For no obvious reason they become sluggish and cease to feed; they contract their body and tentacles, and lie low. They usually tumble off their attachment and lie as roundish or oval clumps on the floor of the aquarium. But after a rest of two or three weeks they revive and recommence normal activity with a new lease of life. In this periodic depression and recovery there is nothing that is inconsistent with what may be called bodily immortality, but, as a matter of fact, the depressions become more and more serious, and eventually fatal. It is very unusual for a captive Hydra to live for more than two years, but it may be that in natural conditions the duration of life is definitely longer. We wonder if the Hydra *must* die? May it not be like the one-celled animals, such as Amœbæ, that seem to be in the main exempt from natural death? From violent death there is of course no immunity.

SPONGES

At first sight sponges do not look like animals at all, and we cannot wonder that early naturalists ranked them among the plants. They are fixed, they have no readily visible way of feeding, they bud and branch. Certainly they are what we should call vegetative animals. Dr. Nehemiah Grew regarded them in 1686 as corresponding to "one half of a plant"—the pithy part. A century later there were many who held that sponges were but the houses of worms, a misinterpretation probably due to the fact that worms are sometimes found burrowing in the interior. Gerarde, in his famous Herbal, figures sponges along with sea-weeds

and mushrooms, and wriggles away from the problem by saying: "There is found growing upon rockes near unto the sea a certaine matter wrought together of the foame or froth of the sea which we call Spunges . . . whereof to speak at any length would little benefit the reader (a warning to us), seeing the use thereof is so well known." But much more interesting than these errors is the extraordinary fact that Aristotle (384–322 B.C.) had reached the conclusion, characteristic of his lucidity, that sponges were animals, though with some likeness to plants.

An English naturalist, Ellis, had pointed out in 1765 that sponges showed their genuine vitality by "sucking and throwing out water"; but the first fundamental observation on sponges is to the credit of a Scottish naturalist, Robert Grant, who had the satisfaction of seeing small particles in the sea-water disappearing into the sponge through minute pores and reappearing at the large exhalant openings. He tells us how, about 1835, he put a little branch of a living sponge in a watch-glass under a microscope, and reflected through the sea-water the light of a candle. "I beheld, for the first time, the splendid spectacle of this living fountain vomiting forth from a circular cavity an impetuous torrent of liquid matter, and hurling along, in rapid succession, opaque masses, which it strewed everywhere around." It is plain that Dr. Robert Grant had the proper spirit, and his vivid drawing of the inflowing and outflowing currents is often reproduced in books of to-day. He guessed rightly that the currents were kept agoing by ciliary action, but he was not able to find the cilia.

If a student of zoology were asked nowadays why sponges are not to be regarded as plants, he would answer that they feed on in-wafted *solid particles*; that the cells of their body are not in the least like those of plants, *e.g.*, in not having cellulose walls; and that the free-swimming juvenile stages of sponges are in a general way like those of many other marine animals.

A living body is often compared to a city, which seems to us a better comparison than likening it to an engine. The quarters of the city, where certain things happen, the

marketing and administrative quarters, for instance, are organs; streets of similar houses or shops, like the old Paternoster Row, are tissues; the houses or shops are the cells; and the inhabitants are the vital units of different kinds that co-operate in a cell-firm. If we compare an ordinary animal body to a city, we must compare a sponge to a city like Venice, where everything depends on the canal system. The canals bring in food and freshness; they sweep away débris and waste; they bring the different parts of the body (or city) into communication with one another.

When we ask Robert Grant's question: What keeps up this twofold set of currents, inhalant and exhalant, we can now give the answer—the ceaseless lashing of energetic internal cells situated on the canal system and whipping the water past. Sometimes the outgush from an exhalant opening is so forcible that it makes a distinct disturbance on the surface of the water a foot overhead. It is possible to fix a glass tube neatly into one of these openings, which often look like the craters of volcanoes, and then one can see the height of the column of water that the sponge's vigorous activity can support.

This shows once more how careful we should be not to judge by first impressions. It seems so obvious that a sponge is a sluggish creature, and yet it is the very reverse. Day and night it is lashing through its body a prodigious quantity of water, and this means a great expenditure of energy. From the water it captures the microscopic organisms and particles on which it feeds, and from the water it captures the oxygen which keeps the fire of its life burning. It is not what you would call a fussy animal, but it does a great deal of work.

Sponges occupy an interesting position in the animal kingdom. They were the first animals to be successful in having a body, and, though they have no organs in the strict sense, they show the beginnings of tissue, especially muscular tissue. When an inquisitive worm pokes its head into an exhalant opening of a sponge, it sometimes happens that the opening is quickly narrowed, though not closed. This means that a ring of muscle-cells has contracted. There is

a peculiar interest in this—namely, that *the sponge has no nerve-cells.* In sponges, the lowest many-celled animals, division of labour is only beginning; and the muscle-cells are not stimulated by nerve-cells as is usually the case. They are themselves directly provoked to action by messages from outside. Everything has its beginning, and in sponges the contractile cells are also irritable.

Some idea of the relative simplicity of sponges may be suggested by the fact that a sponge may be cut into pieces, which all survive. They can be bedded out like potatoes, and the sponge farmers sometimes take advantage of the fact. But the sponge's defiance of death goes much farther. A piece of sponge may be minced, and the mince forced through a straining cloth; a small quantity of this mush will in appropriate conditions pull itself together and develop into a tiny sponge! This means that division of labour has not gone far in the sponge body.

We often hear of the skeleton in the cupboard, but there is more reality about the skeleton in the bathroom. No other skeleton has entered into such intimate relations with human life as the bath sponge. It is a labyrinth of fibres, tough and yet soft, said in a general way to be " horny," but perhaps nearer silk. In association with the spongin there is iodine. The fibres are products of the living cells in the interior of the sponge, and their function is to support the soft tissues. The sponge fishermen expose their captures till the soft flesh begins to decay; then they are beaten or trodden in a stream of water till all the cells are washed out. After the cleaning, which must be done very carefully, the sponges are dried in the sun. When a sponge in domestic use becomes unpleasant and slimy, that is due to gelatinous masses of bacteria which are multiplying in the recesses of the labyrinth. The remedy is to use hot water and a disinfectant, and then dry thoroughly.

When we say " sponge " we always think of the familiar skeleton of the Bath Sponge, Euspongia. But there are, of course, many hundreds of different kinds. Some are on the seashore, like the Purse Sponge (Grantia), whose name recalls Robert Grant, and the Crumb of Bread Sponge, covered with

crater-like exhalant apertures, that forms familiar encrustations on the rocks. Some are anchored farther out, like the Mermaid's Gloves, often tossed up on the beach after storms, and the large Cup-Sponges, and the spherical Sea-Apples. Others, again, are fastened on the floor of the true Deep Sea, like the Glass-Rope Sponge, which is raised out of the ooze on a long stalk of flinty threads, tied together in a firm bunch by a growth of small sea-anemones. Then there is Venus's Flower Basket (Euplectella), which has a flinty skeleton like a fairy campanile. It is an extraordinarily beautiful piece of architecture, but during the life of the sponge it is wrapped up in a garment of cells. The skeleton of a sponge may consist of flint, or of lime, or of spongin (as in the Bath Sponge), or of both spongin and flint. Many British sponges have a large skeleton of spongin, but they cannot be used instead of the Bath Sponge, the reason being that their spongin is associated with myriads of flinty spicules. The effect on the human skin would be disastrous! The spicules often form an internal support, but they also make their possessors practically inedible. There are animals that burrow in sponges, but hardly any animal tries to eat them. In many cases there is also a strong odour, sometimes like iodoform, which is probably repellent.

Like most other animals, sponges may become linked to other lives. Thus there is a bright orange-coloured sponge (*Suberites domuncula*) that grows right over the whelk shell that a hermit-crab has borrowed. It serves as a very effective mask. Several different kinds of crabs, such as the common Sand Crab, are in the habit of sticking pieces of sponge on to their carapace and legs, thus disguising their predatory character under a camouflage of innocence. Within some sponges there occur thousands of microscopic Algæ, plants and animals living together in a mutually beneficial partnership or symbiosis. In the family of fresh-water sponges (Spongillidæ) which have migrated from the original home in the sea, to which all the other families are restricted, the minute Algoid partners are sometimes so numerous that the whole animal is coloured green.

Another curious linkage is illustrated by one of the cuttle-fishes that deposits its eggs in pockets in the substance of a flinty sponge. Interesting also is the habit of the little boring sponge, Cliona, which manages to perforate oyster-shells, and thus helps to reduce a massive bivalve to the level of sand. Some of the boring sponges remain dwarfed like Cliona when they assume the burrowing mode of life, but grow almost unrecognisably large when they live in freedom, which things are like a parable. Our concluding remark must be that sponges represent a cul-de-sac in evolution. They are very successful; there are hundreds of different kinds; they often show great complexity at a low level; many of them are wonderfully beautiful, but they do not lead on to anything else. They are off the main line, and in a blind alley. One reason may be that when the very young stages settle down after a short time of free-swimming, they fix themselves by the mouth—certainly not a progressive thing to do. Another reason may be that they have no nerve-cells, for without these we cannot expect an animal to go far.

XXVIII

THE SIMPLEST ANIMALS

THERE are animals much simpler than corals and sponges. They are microscopic single cells—units of living matter without a true body. Some of them, related to the chalk-forming Foraminifera, creep about on the seaweeds in shallow water, and have very beautiful shells of lime. Others, known as Infusorians, move swiftly about in the water propelled by living lashes (cilia and flagella). One of these Infusorians, called the Night Light or Noctiluca, is about the size of a pin's head. It is brilliantly phosphorescent and makes the oars drip sparks on the late summer evening. Some will entangle on your fingers if you let your hand trail in the water when the boat is moving slowly. Many Infusorians frequent the shore-pools and others live in countless myriads in the open water, where they feed the small crustaceans which feed the herring and the mackerel.

THE AMŒBA

One of the commonest of freshwater animals is also the least familiar; it is the Amœba. And the reason for its not being so well known as it should be is simply that it is usually invisible to the naked eye. Strictly speaking, one should not say the amœba any more than the earthworm, for there are many different kinds of amœbæ, just as there are many different kinds of earthworms. Most amœbæ live in fresh water, creeping on the surface of mud, stones, and water-weed; a few live in damp earth; and some are parasitic inside man and other creatures. Sometimes the number of species has been reckoned at about sixty; at other times it has shrunk to four; the truth is between these extremes. It has been shown that the different kinds of

Amœbæ differ from one another in many details; that they are not more variable than many higher animals are; and that they are not in any very marked way modifiable by environmental influences.

One often envies a naturalist his discovery of a new animal of peculiar interest—the Okapi, Peripatus, the Lancelet, Hydra, the Duckmole, and so forth—and one cannot but envy Roesel von Rosenhof, who in 1755 discovered the Amœba. He not only described the animal, which he called "the little Proteus," he watched the protrusion of finger-like processes of its substance, and noticed that the external changes of shape were associated with an internal streaming—an observation of great importance, as we shall see. A typical Amœba is a complete animal condensed, as it were, into one-hundredth of an inch in diameter. It frequently changes its shape within certain limits, and it glides along in a way of its own. It engulfs food by enclosing its booty between two of the finger-like outflowing and inflowing processes—the "pseudopodia," as they are somewhat absurdly called. When drought sets in or other adverse conditions supervene the Amœba retracts its processes, rounds itself off, and secretes a protective cyst within which it may lie latent for a long time. When there is a return of moisture and prosperous conditions the Amœba emerges from its cyst with a new lease of life.

It has been common to speak of the Amœba as a shapeless blob of structureless living matter, and as if it were a primeval organism. But it is rather changeful than shapeless; it has an internal structure of considerable intricacy; and though its lineage probably goes back for millions of years it cannot be regarded as one of the first organisms. It has a long evolution behind it.

Floating in the somewhat emulsion-like substance of the Amœba there is a kernel or nucleus, and inside this there is a little world. The general substance outside the nucleus consists of living matter with inclusions which are non-living. There are granules and droplets, some with reserve materials and others with waste; there are bubbles of water surrounding food-particles; and there are two

excretory bubbles or contractile vacuoles which expand and collapse continually, somewhat as if they were little hearts. They drain the living matter of its fluid waste and surplus water and open to the exterior. They disappear like burst bubbles and reappear in a few seconds in the same place. Around the margin the substance of the Amœba is firmer and clearer than in the interior, and under the high power of the microscope its margin shows a fine radial striation which reminds one of the transverse markings on striped muscle fibres.

The Amœba is what one might call a many-sided animal, for it can engulf food anywhere, it can contract in any direction, it is susceptible to various outside influences on all sides. It draws away from diverse chemicals ; it draws near to certain foodstuffs ; it is attracted to surfaces on which it can creep. If an Amœba is isolated in the water, it sends out delicate processes on all sides as if groping for some solid basis. When we realise that the Amœba can move, feel, digest, breathe, and excrete just like an elephant, but all within the compass of a hundredth of an inch or less, our respect for the Amœba grows. The puzzle rises how it can do many different things at once in such a small space ; and the solution must be that there is some sort of delicate ultra-microscopical partitioning within the living substance, like the walls separating the different rooms of a great chemical laboratory. This is what is attained in multicellular organisms by having cells. An Amœba is comparable to a one-roomed house in which all the domestic functions go on in orderly confusion, but a higher animal is comparable to a mansion with many rooms—kitchen and dining-room, lounge and laundry, storeroom and drawing-room, and so forth. In other words, there is much division of labour in the higher animal, but there is relatively little in the Amœba. It follows that it is easier to study the physiology of the higher animal, for one function can be tackled by itself—the kidneys, for instance, are distant from the heart—whereas in the Amœba all the everyday functions are going on within a speck that is only a hundredth of an inch in diameter.

When food is abundant and income greater than expenditure the Amœba grows. It increases the amount of its living capital. But it does not grow indefinitely, for each kind of Amœba usually shows a limit of growth—as most animals do. It has an optimum size, when its volume of living matter or protoplasm is as large as the surface can readily keep alive. For as it is through the surface that the Amœba obtains food, oxygen, and water, and gets rid of carbonic acid gas and waste, it is essential that increase of volume shall not outrun the increase of surface. At the limit of growth the Amœba divides into two, the simplest of all ways of multiplying. Occasionally it happens that an Amœba divides into many minute units or spores. And another event is that two Amœba sometimes combine their forces and become one. This is a reproductive process, but it is obviously not a process of multiplication.

As the Amœba has no true body to keep up, being merely a unit speck of living matter, it does not suffer from arrears of wear and tear. It does not get into debt as multicellular animals do. Moreover, its modes of multiplication are so physiologically inexpensive that it is not taxed as most animals are in starting another generation. Natural death is the price paid for having a body, and the Amœba seems to be exempt. Thus our respect for the Amœba increases, for it has organic immortality. It is probable that some of these duckpond Amœbæ which we examine with the microscope, or may see with the unaided eye as minute whitish specks against a dark background, have been living for millions of years. Of course, as we have mentioned, one individual divides into two individuals, and thus in a sense disappears; but we cannot speak of death when there is nothing left to bury!

The Amœba's movements still elude our understanding. They are not random movements, for the Amœba sometimes moves towards a definite goal. They are not "anyhow movements," for when an Amœba is not attracted to or repelled from any particular stimulus it moves in a spiral fashion, like many another animal or like a man swimming blindfold. When looked at very carefully, the Amœba

flowing along—at the rate of some 600 microns (a thousandth of a millimetre) per minute—shows a sort of caterpillar-wheel-like mode of progression. Recognisable particles on the upper surface disappear over the front, and after a short time reappear at the posterior end, to begin once more a forward journey. It would be interesting if the Amœba gliding along or " rolling along " is actually a primeval anticipation of a " tank " !

According to Professor Asa A. Schaeffer's monograph on *Amœboid Movement* (1920) there is in the Amœba, as in some other slowly moving simple organisms, (1) a mobile surface layer, and (2) as in white blood corpuscles and the cells of some higher plants, a streaming in the deeper zones of the protoplasm. The locomotor energy is largely due to surface tension phenomena.

One of the most interesting facts known in regard to the Amœba is that it shows the beginnings of behaviour. It moves towards minute organisms such as diatoms and infusorians ; it folds its protoplasmic arms around its victim, and literally gets outside it. Professor Jennings tells the story of a large amœba (A) which went on the hunt after a small amœba (a) ; for it must be admitted that amœbæ are sometimes cannibals. The large A overtook the small " a " and engulfed it, but " a " used an opportunity afforded by A's locomotion and escaped from its interior. Whereupon A turned from its course and pursued " a," which was captured a second time. But the small " a " had the will to live, which we take to be different from a surface-tension phenomenon, and it escaped again—more of an agent than Jonah ! It was not captured a third time. So here at the threshold of life we find effective behaviour directed towards an end. If an Amœba the size of an elephant came " tanking " down towards us, we do not think we should stop to argue whether it had or had not a purpose.

XXIX

EVOLUTION

THE ABUNDANCE OF LIFE

WHEN Charles Darwin was between sixteen and seventeen years old he went to Edinburgh University to be a medical student; and in his first letter home he gave some of his impressions of the beautiful city. One of the sights that struck him most—"the most extraordinary thing I ever saw"—was the street called "The Bridges." For it crosses over other streets, and when the young student looked over the parapet, expecting to see a fine river, as he says, he saw far below a stream of people. Now that is what we are always discovering in Wild Nature—streams of life that cross one another, no corner unoccupied, mostly full of bustle. There are abundant creatures in the air—clouds of mosquitoes and midges, swarms of locusts, great flocks of birds; there are abundant creatures on the earth—a helter-skelter of rabbits in the warren, such a multitude of tiny frogs leaving the pond in early summer and making for the fields, that we can hardly get past without trampling on some of them. There are abundant animals beneath the ground—we counted forty earthworms' burrows in the circle we described on the golf-links by swinging our club right round at full length. In the Tropics the ants often pour into their underground passages like a living cataract. There are abundant animals in the waters that cover the earth—the salmon so crowded in the Canadian rivers that they choke one another, and the wayside pool so teeming with minute masterpieces that we cannot wonder at Tennyson's remark when he peered in: "What an imagination God has." Then there are the resources of the sea, the schools of porpoises, the shoals of

fishes, and the animalcules on which larger creatures feed—so multitudinous that there may be more of them in a gallon of water than we count of stars on a clear night. Well might Spenser speak of

> "The sea's abundant progeny,
> Whose fruitful seede farre passeth those on land."

Or we might begin again with the Diatoms and other microscopic plants of the open sea, that form what Sir John Murray called "the floating sea-meadows," and picture along the plant line: the multitudinousness in the crowded zone of seaweeds in the shallow well-lighted waters; the dense growth among the mangrove trees on tropical shores—a rank vegetation sometimes breaking off to form floating islands; the luxuriant meadows where so many of the leaves grow upwards, parallel to one another, like the leaves of grasses, so that they do not overlap. There is the keen competition for standing-room, fresh air, and light that goes on in the jungle or the tropical forest, or, nearer home, in the hedgerow that has been left to itself. In plant-world as in animal-world there is the same *abundance of life*—an overflowing profusion.

There are two things to be distinguished—the multitude of individuals and the great variety of different kinds. A codfish is said to produce two million eggs, and it is plain that if all cods' eggs developed into codlings there would soon be an end of all the fishing, for the sea would be solid! There is one of the British starfishes (Luidia) which produces 200,000,000 eggs in a year. An oyster may have sixty million eggs, and the average American yield is sixteen millions. If all the progeny of one oyster survived and multiplied, its great-great-grandchildren would number sixty-six with thirty-three noughts after it, and the heap of shells would be eight times the size of the earth. We know that these possibilities do not happen because *the chances of death are many*; there is continual sifting and thinning. But when there is a vole-plague, or a march of lemmings, or a swarm of locusts, we get a glimpse of what *might* happen if there were not a Balance of Nature.

Some animals multiply much more quickly than others, and it is not always those that are most prolific that get on best. A mother toad may have seven thousand eggs, but all of these do not develop into tadpoles, and all the tadpoles do not change into toadlings, and all the toadlings do not become full-grown toads. The fact is that in many places the number of toads seems to remain very much the same year after year. Life is like the famous Mirza bridge: of the large number that begin to cross only a few get even half-way. Of most living creatures it must be said that the great majority die when they are very young. This is one of the big differences between man and ordinary animals. Man has learned how to avoid the severe thinning that goes on in Wild Nature.

Huge numbers do not always mean that a creature has a very strong foothold. This is well illustrated by the story of the Passenger Pigeon of North America, which flourished in millions not many years ago, and is now gone for ever! It was a strong handsome bird, living in great communities, and often forced to fly far every day to secure food supplies. They say that in some of the forests there were great areas that served as nesting-places, sometimes with a hundred nests on one tree. Of one of these haunts, in the State of Kentucky, a description has been given by an American naturalist, Alexander Wilson. It was estimated to be towards forty miles in length and several miles in breadth, and to contain over two thousand million pigeons, which is more than the whole population of the globe. The pigeons used to arrive at their nesting-place about the 10th of April and leave with their young before the 25th of May, for they were migratory birds, shifting from one part of the country to another.

Mr. D. G. Elliot writes in *The Riverside Natural History* (1888): "The arrival of the great host is an impressive sight. Long before their crowded ranks appear, their approach is heralded by a sound resembling the rising of a gale of wind, increasing in loudness until the birds hurl themselves into their chosen nightly abode, when the din caused by the flapping of myriads of wings, the struggles for a place upon

the trees, the constant change of position, and the crashing of overloaded branches, is so completely overpowering that not only the human voice cannot be heard, but even the discharge of a gun would pass unnoticed."

Birds of prey congregated over the roosting-places and picked fat squabs off the nests. Crowds of people came and encamped near "the immense nursery," and trees were cut down at the proper moment just before the young birds were able to fly. There was slaughter on a huge scale, and gradually, as the years passed, the ranks of the defenceless Passenger Pigeon were thinned, until, at last, all were gone.

The Passenger Pigeon, or "Wild Pigeon," as it was often called in America, was about the size of a turtle-dove, but with a long wedge-shaped tail. It had a remarkable power of rapid and sustained flight, often reaching a speed of a mile in a minute. The male showed a dark slate-colour above, purplish-bay beneath, and had rainbow-like neck-markings; the female showed drab colour above and dull white beneath. They did much harm in the fields, for instance, among the rice. But the chief interest of the Passenger Pigeon for us at present is that it was for a long time prodigiously abundant, sometimes darkening the sky, and yet in a few years it became an extinct species!

A grain of sand is in its proper place on the seashore, but when it gets into the works of our watch we call it dirt. Buttercups are in their proper place in the meadow and celandines in the wood, but both may be troublesome weeds in a garden. Some weeds are very beautiful; and when we call a plant a weed, we do not mean that it is ugly. We mean that it has got out of its natural setting, and that it is spreading without the usual checks on its increase. We get another glimpse of the abundance of life when we notice how weeds run riot and smother better plants. If a garden is left to itself, the weeds will choke many of the flowers in a short time, and then other weeds will choke them. After a few years there may be nothing left except chickweed and bishop's weed and other weeds.

In his *Darwinism* (1899), Dr. Alfred Russel Wallace, Darwin's friend and fellow-worker, gives some good examples

of the spreading of weeds. "Hundreds of square miles of the plains of La Plata are now covered with two or three species of European thistle, often to the exclusion of almost every other plant." The common watercress introduced into New Zealand has grown strong past telling; a stem may be twelve feet long and three-quarters of an inch in diameter. It sometimes chokes a river and causes serious floods; but the useful discovery has been made that if willows be planted on the banks their roots soon become so numerous in the bed of the stream that they crowd out the roots of the water-cress. Set a thief to catch a thief!

There is a common British plant (*Sisymbrium sophia*), one of the hedge-mustards, which often has 750,000 seeds. If all these sprouted, and if the seedlings all grew up and bore seeds, and if this went on unchecked for three years, the whole surface of the earth—about 197 million square miles—would not suffice to contain the weed. We must not suppose, however, that weeds become dangerous simply because they have very numerous seeds, for there are many, such as buttercups, which bear only a few. Weeds become dangerous when they get into a new place where they are free from the sifting and singling that usually keep their numbers down. Suppose a plant had only two seeds and lived only for a year, it would be represented in twenty-one years by a progeny of 1,048,576 plants, provided that animals did not eat them, provided that their neighbours did not smother them, provided that all the seeds every year were properly scattered and landed in suitable places. Fortunately for us, these "provideds" do not happen.

Just as we speak of icebergs—floating mountains of ice, separated off from the shore-ends of great glaciers, so we may conveniently speak of bird-bergs, meaning those great sea cliffs, often islands, where birds nest in enormous numbers. There are many of them on or off northern coasts. For Britain we may name Flamborough Head, the Bass Rock, Ailsa Craig, Fowl's Heugh, and Foula. These places have this in common, that there are thousands of ledges and niches on which the birds can rest and nest; and these are tenanted by more or less similar birds, some staying through-

out the year, like cormorants and kittiwakes, others remaining for the breeding season only, like guillemots and puffins.

A visit to a good bird-berg gives us more than a glimpse of the abundance of life. We went to one called Handa Island. It lies about a mile off Scourie, on the west coast of Sutherland.

Handa is built of layers of sandstone and pudding-stone (conglomerate); it has a long grassy slope towards the mainland and precipitous cliffs to the north and west. To the north it looks on Greenland, to the west on the Butt of Lewis and the hills of Harris. The island feeds about 300 sheep and many rabbits. There used to be a few houses, but now there is only a shelter for the shepherd who comes over for six weeks at lambing time. We mention this because the small number of visitors accounts in part for the extraordinary tameness of the birds. They allow one to come within a few feet of them, but one must be careful of the precipices.

We climbed up the long grassy slope and came suddenly to the edge of a precipitous sea-cliff a hundred and fifty feet high, built up, like a giant's bookcase, of shelf after shelf of sandstone. The shelves were from a foot to a foot and a half in breadth, and they bore tens of thousands of birds, often packed so closely that their bodies were touching and their necks crossing. In most cases the various kinds of birds were quite separate, living, as it were, in different streets of "Cliff-Town." Lowest down there were kittiwake streets; then a guillemot or razor-bill section with about thirty shelves one above the other; and then at the top, where the turf began, there were the burrows of the cheerful puffins. In some places there was a section of rock-face with guillemots only; in another place there were more razor-bills, easily distinguished from their cousins by the compression of the bill from side to side. Here and there a kittiwake had established a claim to a broad bracket of rock projecting by itself, and sat there on its nest surrounded by thousands of guillemots.

We went higher and higher, walking carefully along the edge of the cliff—for who can tell when a slice will slide off? —and we came to a stretch of three hundred yards, where the cliff was four hundred feet high. We saw the abundance

of life — the long terraces, tier above tier, of kittiwakes, guillemots, razor-bills, and puffins. On some shelves the guillemots and razor-bills were able to stand upright with their white breasts turned seawards, but most had their backs outwards and their bodies pressed against the rock. The long webbed feet must be of use in gripping a downward sloping shelf, but it was interesting to notice that the foot-hold was often lost when an extra bird arrived from the sea and insisted on landing on a shelf already full. There was plenty of fighting and murmuring, and the noise was sometimes deafening, but on the whole it was a good-humoured crowd, and there seemed to be a good deal of give and take. We saw nothing like interference with the young birds, who were nearly ready to fly away. It was difficult to believe that in a few days there would not be a single guillemot, or razor-bill, or puffin left on the cliff. All disappear before the end of July, making for the open sea and the coasts of southern lands. For the three birds we have named are only summer visitors to Britain.

On a section of the cliff, 400 feet high and about 300 yards in length, we tried to make some rough estimate of the number of birds, and our conclusion was that there were 400,000 at least. Why were there so many? The first part of the answer is that as the number of suitably shelved cliffs is not very great, birds gather from far and near, and return season after season. The second part of the answer is that the birds have few enemies except man. The sea-eagle or erne is now very rare; the buzzards, which still frequent Scourie, can hardly venture among the legions of sharp-billed guillemots; and it is not likely that the greedy Great Black-backed Gulls, that we saw sailing about, get more than the weaklings. Some of the young birds fall off the shelves or may come to grief when they make their first venture on the sea, but on the whole they do very well; and it should be remembered that guillemots, razor-bills, and puffins lay only one egg at a time. But the third part of the answer is simply that there are so many fishes in the sea. The multitudes of fishes—we saw the birds carrying them in their bills as food for the young ones—make the multitudes of birds

possible. And the fishes depend upon crustaceans, and these on microscopic animals and plants. That is how the world goes round!

DIVERSITY OF LIFE

There is something impressive in an enormous flock of sheep that takes an hour to pass by, or in a huge congregation of rooks darkening a field, or in thousands of starlings swirling above their resting-place for the night like clouds of hot dust from the crater of a volcano, or in a shoal of mackerel, or in a swarm of bees, or in the thronging multitudes of ants that we see in a big ant-hill, or in a fleet of jellyfishes through which we row the boat all the afternoon, but there is something much more interesting than the dense peopling of some corner by one kind of creature. What is much more interesting is the variety of different kinds of creatures. To take a very moderate estimate, there are 25,000 different kinds of living Backboned Animals (or Vertebrates), named and known, including mammals, birds, reptiles, amphibians, and fishes. And to this long list must be added a huge number of extinct Backboned Animals, especially fishes, which are only known as fossils in the rocks —the graveyards of the buried past.

But when we turn to Backboneless Animals (or Invertebrates), the number of different kinds, named and known, is enormously greater, it is at least a quarter of a million. It must be admitted, however, that four-fifths of these are jointed-footed animals, especially insects, but that leaves 50,000 for molluscs, worms, star-fishes, stinging animals, sponges, and single-celled creatures. To this huge Invertebrate list there must again be added a vast number of fossil animals, which have had their day and ceased to be.

On a clear night one can see between four thousand and five thousand stars with the unaided eye, but as many new kinds of insects are sometimes discovered in a single year. Or, we may say that there are one-tenth as many different kinds of birds on the British list as we can see of stars on a clear night. The British list stands at present at about 460 different kinds of birds—many of them great rarities.

It may be interesting to give a few details of the census of living animals, but it must be understood that the figures are only approximations :

Backboned Animals	Mammals .	2,850	25,000 species.
	Birds . .	10,000	
	Reptiles .	3,500	
	Amphibians .	1,000	
	Fishes . .	7,500	

Backboneless Animals : 250,000 species.

As for plants, there are said to be about 50,000 named and known, and of these about half are flowering plants. Thus we see that there are far more different kinds of animals than there are of plants ; but when a particular kind of plant, such as a grass, finds a very suitable place, the number of individuals soon comes to be far in excess of anything that is to be found among the larger animals. One of the reasons why there is greater variety among animals than among plants is simply this, that the great majority of plants (making exceptions for those that live in water and those that are perched on other plants) must be rooted in the ground. There are not open to them so many "chances," so many niches of opportunity, as are open to animals that can move about and burrow and climb and fly. In other words, experiments pay better among animals than among plants. It may be said that most plants play a waiting game, though they also have their ventures—in the Venus Fly-Trap for instance.

Large numbers do not really make much impression on us. It is more useful to go out with a botanist and sit down on the links, and then without rising he will often be able to show you a dozen quite different kinds of plants within reach. After walking for a mile to another sort of place he will do the same thing again, but it will be another dozen plants this time ! If you sit down on the dry sand of the shore near the high-tide mark, you may quite easily find within reach of your arm a dozen different kinds of small animals, or parts of them at least. We once dredged up a stone with fourteen different kinds of animals fixed to it !

There are two rather difficult points that require clearing up. There are some fossils in the rocks which have their living counterparts in the sea to-day. Such is the Lamp-Shell, Lingula, which flourished millions of years ago and is flourishing still. No one would count in the census both the living animal and the fossil, for that would be counting the same creature twice. But there are fossilised animals which were the ancestors of some animals now living, and are more or less different. Thus three-toed extinct horses were the ancestors of the modern horse which walks and runs and jumps on the tip-toe of one digit in each limb. It is clear that the three-toed horses must go down on the list as well as the living kinds of horse. There is a very interesting Mudfish in Queensland rivers called Neo-Ceratodus, which breathes by a lung as well as by gills, and helps to link fishes to amphibians. Now this curious double-breather was represented long ages ago by a slightly simpler ancestor called Ceratodus, and both must be entered on the census paper. Once more, there are in the fossil-bearing rocks not a few extinct animals which are not known to have any living descendants to-day. They represent *lost races*; they have been blotted out entirely. Such, for instance, are the Flying Dragons, which did *not* lead on to birds, and the Fish-Lizards, and the ancient Sea-Serpents, and the huge Sea-Scorpions. But they must be included in the Roll of Honour. They were once as living as we are. Is it quite clear then, that fossils may be (1) the petrified remains of animals that lived long ago but are carrying on still; that they may be (2) the ancestors of present-day kinds: and that they may be (3) the remains of lost races which have no direct descendants in the Animal Kingdom of the present day?

The second difficult point is this: What do we mean by "a kind"? What is it that we count in the census of animals and plants? A kind or *species* means a group of individuals that agree in many features and show these with some constancy generation after generation. The members of a kind or species can all breed among themselves, but they do not readily breed with related species. Thus hares

and rabbits never cross. And the features in which the members of a kind or species agree, and on account of which they get a special name, must always be bigger than the individual features that distinguish the members of a single family. There are many different colours of shore-crabs, but it would never do to give these different species names, for the same differences in colour may be found among the brothers and sisters of a family. The peculiarities of a species must be important enough and constant enough to deserve a special name. That special name is always written second: thus Passer *domesticus* is the House Sparrow as distinguished from Passer *montanus*, the Tree Sparrow. Thus Felis *leo* is the lion, Felis *tigris* the tiger, Felis *catus* the Wild Cat, and so on—different kinds of "cats" within the larger group or genus Felis. Sometimes there is only one species in a genus—thus there is only one "New Zealand Lizard" (Sphenodon); or one species of a genus in the country, thus there is in Britain only one kind of kingfisher (*Alcedo hispida*). The difficulty is when there are many nearly related kinds, say of trout and char, bramble and willow. Then naturalists begin to quarrel about what a "good species" is.

THE PEOPLING OF SEA AND LAND

All the world is a stage, and on that stage for many millions of years there has been played the drama of animal life. The actors have changed in the course of ages—becoming on the whole finer, and the stage has changed—becoming in many ways more beautiful; and the plot has changed—becoming more and more intricate. But while everything changes there is a sense in which everything remains the same. The stage is the same old earth, the actors and actresses are living creatures all akin, and the acting never gets very far away from the two great motives of Hunger and Love. As the poet has said: "While philosophers are disputing, hunger and love solve the world's problems."

Always, at any rate, we have to do with three great

things: the stage, the actors, and the acting. In the language of Biology, the three great facts are ENVIRONMENT, FUNCTION, ORGANISMS.

The kind of activity which we call "living," which is so difficult to understand, consists mainly in thrust and parry between plants and animals and their surroundings. But as we ascend the scale, the inner life of thinking, feeling, and willing counts for more and more.

As we watch a countryside from year to year, we see changes going on—more marked in some parts of the country than in others. An old naturalist once showed us a little island in a river, an island with willows and alders on it, and told us that he had seen that island grow from nothing in the course of his life.

Sometimes a flood changes the appearance of a great stretch of valley and alters the course of the river. Sometimes a forest fire spoils everything for many a year, changing the plants and animals as well as the general appearance of the region. Sometimes a severe storm takes a big slice off the cliffs or buries several farms in sand. If such changes can be seen in a short time, we can understand that a great deal may happen in many millions of years. This is very important, because part of the drama of life consists of the answers-back that living creatures make to the changes in their surroundings.

The rain caught in the crevices of the rocks freezes, and bursts the fissures as if by a thousand wedges; runlets of water carry away the fragments and grind them into sand in the bed of the stream; the sea hurls stones against the base of the cliff and we can hear them battering against one another; the glacier carves out a valley and gouges out a lake; and on a larger scale, there are volcanic eruptions and bucklings of the earth's crust. In scores of ways—a great study in itself—the surface of the earth has changed from age to age, and what is weathered off at one place is laid down somewhere else to form the raw materials of rocks that are yet to be. Given enough of time, and the mountains will flow down to the sea, and dry land will appear in the midst of the ocean.

The stage was not very promising to begin with :
They say

> " The solid earth on which we tread
> In tracts of fluent heat began,
> And grew to seeming random forms,
> The seeming prey of cyclic storms."

Our first picture is the smoking, cindery crust of the cooling earth—not yet fit to be a home of life. Even the atmosphere was depressing, for it consisted mainly of carbonic acid gas, water vapour, and nitrogen. There was very little oxygen, for most of the atmospheric oxygen, on which almost all living creatures depend, has been made from CO_2 by green plants working in the sunlight.

But the crust of the earth became cooler and water vapour was condensed into little pools of water. These grew and flowed together into great seas, which dissolved salts out of the crust. Perhaps those authorities are right who believe in a period of universal ocean covering the whole earth. But whether we picture one great ocean or many seas matters little, we must add to our picture crowds of minute forms of life, betwixt-and-between creatures, half plants half animals, swimming about in the water. We do not know how they came into being. They fed on air, water, and salts ; and they began the process, on which everything else depends, of splitting up CO_2, fixing the carbon, and liberating the oxygen. It has been recently discovered that if certain rays of light be passed slowly through a mixture of water and carbonic acid gas (carbon dioxide) there is formed a simple carbon compound (CH_2O) called formaldehyde. This was what the first living creatures learned to do, millions of years ago, and this is what every green leaf is doing every day.

By a buckling of parts of the crust of the earth, continents were formed and deeps between. In the shallow waters near shore a new opportunity was offered ; it became possible for some of the more plant-like primitive creatures to settle down without losing the light. They would begin to grow out into threads and plates ; the race of seaweeds began, and every one should make an expedition to the

seashore rocks at the lowest tide to get a good view of this very ancient, very varied and beautiful vegetation.

Some of the simple plants might gradually find their way through estuaries and swamps into fresh waters, and thence as liverworts, mosses, ferns, on to more or less dry land, where eventually flowering plants appeared. But there are some botanists, like Dr. A. H. Church, who believe that when a slow raising of the beach occurred, and it happened often, there came about a gradual transformation of some of the higher seaweeds into land-plants with true roots and leaves. In any case, water-plants gave rise in the course of ages to land-plants.

But we must go back again to the shallow waters near shore. For it is highly probable—that is all we dare say—that among the simple creatures that were beginning to be thoroughgoing plants, there arose another kind of creature, the first thoroughgoing animals. They were predatory; they could no longer feed on air, water, and salts; they stole what the plants had manufactured. As they fed on complex ready-made food, like sugar and other carbon compounds, they gained a great deal of energy and began to live a stirring life. They tried experiments along many lines and gave rise to sponges, zoophytes, corals, and jelly-fishes, and in the course of ages to all the great abundance of the sea.

It is probable that the first animals lived in shallow water near shore, creeping or swimming about among the seaweeds. But some naturalists think that animals began in the open water farther out. We cannot decide between these two views, but it seems safe to say that the cradle of life was either the Open Sea or Near Shore. The original home could not be the dark floor of the sea, for that is too difficult a place for the beginnings of life. It is too much shut off from the sun, which is the great source of power. We may also exclude the dry land, for that is a difficult home for simple forms of animal life; indeed it was not a place for animals to live in until plants led the way.

We may venture to say that every race of animals that has got on well on land came from a stock that served a long apprenticeship in the water. Mammals and Birds sprang

from Reptiles, Reptiles from Amphibians (half in water, half on land), and Amphibians from Fishes—which can rarely leave the water except for a short time.

There remains the possibility that the simplest kinds of animals began in fresh water, but there are some reasons against this view. The oldest fossil-plants are seaweeds, and the place where the plants began must have been the place where the animals began. The oldest animal fossils in the rocks are mostly related to animals that now live in the sea, such as jellyfishes, corals, sea-lilies, and lamp-shells. If you inquire into the first animals that gained true bodies, namely, the sponges, you find that there are many hundreds of different kinds in the sea, but there is only one family of sponges in fresh water. That tells a tale. If you inquire into the next great group of animals, namely, the Stinging Animals, you find that there are thousands of different kinds in the sea—zoophytes, swimming-bells, jelly-fishes, sea-anemones, and corals—but only about half a dozen different kinds in fresh water. This also tells a tale. *The sea is the original home.*

One other argument, and a curious one. When we cut our finger and put it to our mouth we find that the blood has a salt taste. There are several salts carried in solution in the blood, and they are the salts that are commonest in sea water. Moreover, the proportions in which the various salts occur in the blood are very nearly the same as the proportions in which these salts occur in sea water. This must mean that when blood was first set apart very long ago as an internal fluid in the body of animals, it was a fluid not very different from sea water except in this that it contained dissolved food. It is difficult to avoid the conclusion that the first animals with blood, represented to-day by worms called Ribbon Worms (or Nemertines), lived in the sea.

It comes to this then, that to our question: Where did animals begin? we must give the answer: They began in the sea, either in the Open Sea or in the shallow water near shore among the seaweed. Our own view is that the first living creatures to be very successful were Open Sea creatures, half plants half animals, able to swim about by means of an

undulating living lash (or flagellum), and able to feed on air, water, and salts. At a later stage, after seaweeds had begun to flourish on the floor of the shallow water, there arose the first animals—living on minute plants and on the microscopic fragments of plants. In the Open Sea to-day there are vast numbers of lashed organisms or Flagellates which seem still hesitating between the Vegetable and the Animal Kingdom.

If the first genuine animals began among the seaweeds in the well-lighted shallow water near shore, their first enterprises had to do with making the most of their territory. For there are different zones in the shore area, and each zone in turn was explored and colonised. Thus there were some animals that got on best among the red seaweeds which grow farthest down the sloping floor. Others flourished better among the brown seaweeds, like the tangles and the kelp. Others, that wanted all the light they could get, settled down among the green seaweeds, like sea-lettuce, in the shore pools. It may be explained that *all* the seaweeds have *green* colouring matter (chlorophyll), by means of which they are able to utilise the sunlight, but it is masked in the browns and reds by other pigments. Finally, the most adventurous animals of the seashore area found their way into the zone between tide-marks, and obviously the only kinds that could flourish there would be those that were able to endure being left high and dry when the tide is out, as we see to-day in limpets, whelks, acorn-shells, and many more.

Many of the seashore animals are fixed, like sponges and zoophytes and sea-anemones, but others are swimmers, and it would naturally come about that some of these would venture farther and farther from the land and become Open Sea animals. There would be two great inducements : first, that much of the floating food tends to be swept out to sea ; and second, that the Open Sea is a quieter and less upsetting place than the shore.

But there is another way in which additions might be made to the Open Sea population. Many shore animals have young stages that swim out or get carried out to sea. This is well, for they are too delicate to stand the rough-and-tumble life of the shore, the hammering of waves and

tides. Thus the young stages of shore-crabs, acorn-shells, starfishes, sea-urchins, and many more spend the early part of their life in the open waters, returning to the shore when they are fully-formed and tougher in build. Now it may be that some of these Open Sea young stages (pelagic larvæ, as they are technically called) remained in the open waters and started a new type of animal suited to that kind of life. Of course this would not happen quickly, but it might happen in the course of time. There are some animals of the Open Sea which look a little like children that have not grown up (permanent larvæ). Such, for instance, is Trochosphæra, which is very like the trochosphere larva of a sea-worm.

Let us take another, slightly different, illustration. Many of the plant-like Zoophytes (or Hydroids) of the shore-area bud off in the summer season beautiful swimming-bells (or Medusoids), which are often set adrift. They swim about by pulsating their bell, and they are almost as clear as the water itself. But one can sometimes see the mouth hanging down, like the clapper in the middle of the bell. Many of these Swimming Bells are not bigger than blackcurrants, but some are the size of walnuts or larger. Their tentacles have stinging cells which benumb and grapple the minute animals on which the Swimming Bells feed.

Now these Swimming Bells produce eggs and male elements, and from the fertilised eggs there develop free-swimming embryos. Eventually the young forms, which are very minute, settle down on stones and shells and sea-weeds in inshore waters, and grow, by budding and budding hundreds of times, into the colonies that are called zoophytes. The story is an intricate one, but of great interest.

ZOOPHYTE→BUDS OFF SWIMMING BELLS→WHOSE FERTILISED EGGS DEVELOP INTO FREE EMBRYOS→WHICH SETTLE DOWN AND GROW, BY BUDDING, INTO→ ZOOPHYTES.

This is what is called *alternation of generations*, and it has a curious parallel in the life-histories of Mosses and Ferns.

But the point at present is this, that there are in the Open Sea a number of animals like Swimming-Bells, but having no connection with zoophytes. It is possible that these arose from Medusoids which suppressed the sedentary zoophyte stage altogether, and, as it were, severed their connection with the shore. Among animals with complicated life-histories we can often discover a tendency to lengthen out one chapter and telescope down another.

From the end of the well-lighted shallow waters, and that means the end of the seaweeds, the floor of the sea slopes down, sometimes gradually, sometimes steeply, to the great depths. At a certain distance on the downward slope there is "the mud-line," the last zone where there is an abundant deposit of the fine sediment from the shore. The deposit consists partly of rock-dust and partly of minute particles broken from seaweeds and shore animals, both living and dead. In the deposits of this "mud-line" there is a great congregation of animals, such as worms and bivalves, brittle-stars and sea-cucumbers. They are chiefly what may be called "soft-mouthed" animals which feed on minute organisms or particles, in contrast to "hard-mouthed" animals, like crabs and cuttlefishes, which have strong jaws suited for eating what is hard or tough.

As the "crumbs" of the shore sank farther and farther down the slope, some shore animals followed them, and became suited to living in the dark, cold water of the great depths. It was in this way, we believe, that the animals of the Deep Sea originated, for there is often a distinct relationship between the animals in the great depths and those living in the nearest shore waters. Sometimes, moreover, a section of the crust of the earth was depressed and a stretch of shore gradually sank into deep water, and this might be another way in which Deep Sea animals began. But it should be noticed that only a few of the animals now living in the great abysses of the ocean can be regarded as very old-fashioned or primitive.

The Common Flounder is often found up rivers at a distance of a dozen or more miles from the sea. This is very interesting, for most of the Flounder's relatives, like

the Sole and the Plaice, are confined to the salt water, and there can be no doubt that the Flounder was originally a sea fish. It is learning to live in fresh water, but it has to go to the sea to spawn, and the early life has to be passed in the sea ; but the story of the Flounder shows us how the colonising of the fresh waters might *begin.* If a fish, making experiments like the Flounder, should learn in the course of time to spawn and develop in fresh water, that would help still further to clear up the rest of the problem : How were the fresh waters peopled ? The supposition we have made is not a wild one, for there are some fishes that can stand both salt water and fresh. Thus the Three-spined Stickleback makes its nest in ponds and rivers, but it may also be found in shore pools and in the sea itself. There are other fishes, such as the Salmon, Shad, and Sea Trout that can pass from salt water to fresh, and this may have been one of the ways in which the fresh waters were peopled.

Another thing that may sometimes have happened is this : an arm of the sea might, by changes of level, come to form an inland lake, whose waters might gradually become fresh through the inflow of streams and under the influence of aquatic plants, which captured and imprisoned some of the salts. There is a beautiful water-snail in Lake Tanganyika, by name *Typhobia horei*, whose relatives live in the sea, and a fact like this shows us that some present-day fresh water animals may once have lived in the sea or had ancestors that lived in the sea. An interesting case is the presence of seals in Lake Baikal in Asia—a great lake far from the sea. Of course, seals are marine mammals, not fresh water mammals, but they live in Lake Baikal because it was once part of the sea or closely connected with it.

In the Far East of the Indian Océan, two hundred miles south of Java, there lies a small island called Christmas Island. It used to be a great haunt of birds, they say, for there are thick beds of phosphate salts, very valuable as fertilising manure, and these seem to have been due to the droppings of birds, accumulating for ages. The late Sir John Murray, one of the founders of the Science of the Sea (Oceanography), discovered the value of the island in

the course of the *Challenger* Expedition (1873–1876), and the British Government was more than repaid for the whole cost of the expedition by the royalties obtained from the sale of the phosphates. The bird droppings, turned into rock, were carried away in ships to agricultural countries, and transformed to make food for growing corn and other plants; but why we wish to think of Christmas Island just now is because it is one of the homes of an extraordinary animal, the Robber-crab (*Birgus latro*), particularly interesting because it is one of the invaders of the dry land. It is a biggish animal, sometimes a foot long and six inches broad, more nearly related to hermit crabs than to ordinary crabs, but originally a marine animal beyond doubt. It must have an adventurous spirit, for it explores the island a long way from the shore, and it climbs the coco-palms for the sake of the nuts! After it has torn off the fibrous husk, out of which coco-nut matting is made, the Robber-crab hammers with its great claw at one of the dimples at one end of the nut. It breaks a hole through and, putting in one of its narrower legs, it spoons out the sweet milk. The Robber-crab gets its name because it is fond of coming near houses or workshops, and stealing things; sometimes it has been known to make off with an empty meat tin, using *that* as a protection for its tail!

Most animals that live in water breathe by gills, as we see in lobsters and fishes, and these gills are feathery outgrowths inside which the blood is spread out so as to capture oxygen from the surrounding water. A gill is like a down-feather, or a country with a much indented coast line, in that it has *a large surface*, and as the water washes this there is abundant opportunity for the oxygen to diffuse in and for the waste carbonic acid to diffuse out. Breathing always means the intake of oxygen, and the getting rid of carbon dioxide ($+O$; $-CO_2$). Now the question arises: How a marine animal with gills can breathe dry air on land. For most land animals breathe by lungs, or something like lungs, hollow sacs *inside the body*, on the walls of which the blood is spread out. Now the Robber-crab still retains traces of gills, but on the wall of its gill-chamber there are numerous

delicate projections which contain blood and absorb dry air. As regards its breathing, it is a betwixt-and-between animal.

Once a year the Robber-crab gives away its secret. It has to go back to the seashore to spawn. The eggs are liberated in the sea, and the young ones spend some time as free-swimming larvæ and then as creeping creatures on the shore. After they have grown strong they begin to explore the dry land. Long before that, however, the parents have scuttled back to their home among the coco-palms.

A very interesting point is that the coco-palm is not a native of Christmas Island, or of any of these Eastern islands, where it has established itself in a sort of chance way, probably through the nuts being carried by ocean currents. It follows that the Robber-crab must have learned to climb the coco-trees and break off the nuts within *comparatively recent* times.

We have taken the Robber-crab as a sure and certain illustration of the way in which some animals have left the sea and invaded the dry land. It does not stand alone, for there are many land crabs in different corners of the earth —all requiring to go back to the water to start the next generation.

If you turn over loosely lying stones or break off big pieces of bark from a felled tree that is beginning to decay, you see squat wood-lice running quickly about. You will also find their " moults "—the dead husk (or cuticle) which is stripped off from time to time to let the animal grow bigger. If you take this " moult " on your hand, you will see that it is like a ghost of the living animal. It has been shed from the whole surface of the body, somewhat like a snake's " slough," and it shows the husk of all the limbs. If you try to count the limbs on the husk or on a dead wood-louse, using a pair of mounted needles to separate part from part on a piece of black paper, you will not count them right the first time ! When you do count them right, the answer will be nineteen pairs. Why should this be interesting ?— because almost all the lobsters, shrimps, and prawns have nineteen pairs ; and the occurrence of the same number in

the wood-louse is one of the many proofs that this land animal has sprung from the marine sea-slaters (technically called Isopods). Some of these are often found between tide-marks, as if beginning the exploration which the wood-lice have finished.

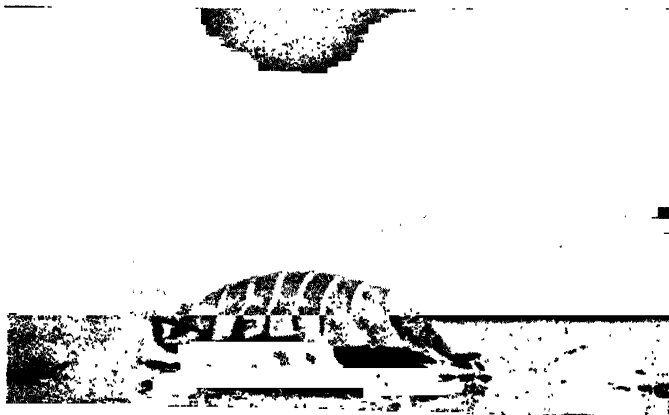


Photo : John J. Ward, F.E.S

WOOD-LOUSE (*Porcellio*).

Wood-lice are flattened terrestrial crustaceans that have left the water. They are included in the order of Isopods, sub-order Oniscoidea. The number of appendages is the same as in lobsters, prawns, and crayfishes, namely nineteen pairs. The abdominal limbs are traversed by minute tubes which serve for breathing moist air.

But when we inquire further into the matter we find that there are a number of " slaters " living in fresh water, and this makes it probable that the terrestrial wood-lice were derived from a fresh-water stock, which in turn had its ancestry on the seashore. In the same way it may be argued that the earthworms, which are among the most terrestrial of all animals (eating the earth as well as burrowing in it),

sprang from a stock of fresh-water worms, and it is interesting to remember that there are several earthworms, such as those called Alma and Dero, that have tiny gill-like outgrowths near the head end.

There were, in the course of ages, three great invasions of the dry land, and each of them had very important consequences. First, there was the *Worm Invasion*, leading on to the earthworms of to-day and resulting in the making of vegetable mould and fertile soil. Secondly, there was the *Centipede-Millipede-Insect-Spider* invasion—jointed-footed, air-breathing animals—the greatest result of which was the linking together of flowers and flower-visiting insects. Thirdly, there was the *Amphibian* invasion, starting probably from pioneer fresh-water fishes. From the ancient Amphibians, with one foot in the water, so to speak, and the other on land, there sprang Reptiles, free from the water altogether, unless they went back to it on a new tack; and from the Reptiles there sprang both Birds and Mammals, so that the grand result of the third invasion was that it started the Higher Animals on their adventurous career.

There were minor invasions of the dry land, such as those led by Crustaceans like the Wood-lice and the Robber-crab, or those led by certain Water-snails—the ancestors of our land snails and shell-less slugs. But the three great invasions were the Worm Invasion, the Insect Invasion, and the Amphibian Invasion, for they *made history*.

The dry land is a haunt that tests the mettle of an animal. For the freedom of movement is less than in the sea, so the movements must be nimble, or else there must be some cloak of defence or concealment. The changes of day and night, of summer and winter, are more felt than in the sea, so there must be something in the way of protection. There are risks of being dried up, of being blown away, of being buried alive, and so on, and we find among land animals a great many ways of avoiding these and other dangers. No sooner did animals get on to the land than they tried to get away from it! Some became burrowers, like the earthworms; some went up trees, like tree-frogs; some hid during the day and came out at night, like slugs.

But the best and biggest change was to get into the air. And there have been in the course of the history of Living Creatures four great invasions of the air. First, there was the Insect invasion—leading on to our dragon-flies and midges, butterflies and bees. Secondly, there was an invasion that was successful only for a time, that of the Flying Dragons or Pterosaurs, which varied from the size of sparrows to a span of fifteen feet. But they did not last. Thirdly, there was the Bird invasion, extraordinarily successful as every one knows. And fourthly, there was the invasion of the air by Bats—mammals that can fly.

THE PROGRESS OF LIFE

Millions of years ago plants and animals had spread over earth and sea, and had established themselves in every possible place, except that there were no plants in the dark abysses of the ocean. But this peopling of earth and sea might have taken place without there being very marked progress towards fullness and freedom of life. In man's case we know that simple peoples spread over earth and sea in very ancient days before there was much in the way of civilisation. Both with living creatures and with men there were long ages of *possessing the earth* before the biggest strides of progress were taken. We have pictured some of the changes in the world stage; let us think for a little of the changes in the actors and actresses.

In the *Arabian Nights* and similar old stories we read of the way in which a genie could change in a moment from one shape to another. What was a bird one moment was next moment a snake, at the next a fly, and again a grain of corn! Now during the millions of years since living creatures began to be upon the earth, there have been ceaseless changes from form to form, but differing from the genie's changes since they took place very slowly and were never magical. Nor was it that an individual plant or animal changed greatly—though that may happen when it is taken to new surroundings—it was rather that the children differed from their parents and from one another. We see these changes to-

day when a hornless calf or a tailless kitten appears in a horned or tailed race, or when a white blackbird is hatched out, or when a black sheep is born, or when a copper beech suddenly appears, or a weeping willow, or a "wonder-horse" with its mane reaching the ground, or a pigeon with twice the usual number of feathers in its tail, or a Greater Celandine with its leaves all cut up, or a Chinese dog without hair, or a guinea-pig with an extra toe, and so on, and so on. Some plants and animals are much more changeful than others, and some are changeful for a while and then more stable; but the great fact is that from generation to generation novelties are always cropping up. The possessors of these novelties (called variations and mutations) are sifted in the struggle for life and endeavour after well-being, and the more advantageous succeed, whereas the less suitable are pruned off so that they leave no descendants or less than the usual number. Professor Punnett has calculated that if in a population of a thousand animals there arise at any time 10 per cent. of similar novelties with a 5 per cent. advantage in their favour, then in 100 generations all the populations will be like what once were novelties.

If we visit a dog show we see and hear an extraordinary assemblage—airedales, bloodhounds, collies, dachshunds, Esquimo-dogs, fox-terriers, greyhounds, and so on through most of the letters of the alphabet, but all of these are descendants of the wolf and the jackal, or one should say of various wolves and jackals. Novelties cropped up from time to time—no one is very sure *how*—and man picked out those that pleased him most, and, keeping them apart, bred from them till he established race after race of domesticated dog. If man has done this in a comparatively short time, what may Nature not have done in a very long time, the struggle for existence doing automatically what man does deliberately—picking and choosing, pruning and sifting?

If we visit a pigeon show we see fantails, pouters, tumblers, jacobins, homers, barbs, and how many more, all descended from the wild Rock Dove, which still lingers in the seashore caves of Scotland and elsewhere. Man has established all these breeds out of the novelties supplied from the domesti-

cated descendants of the Rock Dove. If he has been able to do so much in a short time, what may not Nature have done in the long time that has elapsed since the first bird appeared in the Jurassic ages—millions of years ago ? The same sort of question arises in our mind when we look at all the different kinds of apples which man has been able to establish by taking advantage of the changefulness of the crab-tree by the wayside and of its descendants when the process of cultivation got going. Or think of the different kinds of cabbages—cauliflower, broccoli, brussels sprouts, curly greens, and others—all derived from the wild sea-kale found growing on the seashore.

The ancient crust of the earth was buckled up here and depressed there, so that continents and ocean-basins, highlands and lowlands, were formed. But the raising of the crust meant weathering and the carrying away of mud, sand, and gravel, which were deposited elsewhere, pressed and hardened into shales, sandstones, and pudding-stones. So the earth got layer after layer, skin after skin, of second-hand rocks, and the oldest are on the whole lowest, though there were often strange tiltings and other disarrangements. In many of the rocks that had been formed from deposits on the floor of ancient seas and lakes, there are the remains of plants and animals that lived at the time, and it is from these *fossils* that we can read the past history of life with most security. The rock record is like a library in which all the oldest books were originally on the lowest shelves and the later books on successively higher shelves, with the modern books highest of all. Unfortunately, however, the shelves have been broken a good deal and there has been damage done by fire ; moreover, a great many volumes are missing, so that most of the sets are incomplete. But in spite of all that, one can see in a general way how one literature has succeeded another as the centuries went past.

So it is with the fossil-bearing rocks. They cannot lie, but they require careful reading. What they show plainly is this, that for long ages, extending over many millions of years, the only animals were backboneless animals, such as sponges, corals, worms, sea-lilies, trilobites, and lamp-shells.

Ages passed and fishes appeared, first gristly and then bony. More ages passed, and in the time called the Old Red Sandstone Age there appeared the first Amphibians. The Backboned Animals had now found a foothold on land, but there was no hint as yet of anything higher than Amphibians, distantly related to our frogs and toads. Amphibians had a "golden age" in the Carboniferous Epoch, when the great coal-beds were formed from the débris of huge swampy forests of horse-tail and club-moss trees. And in the next epoch (the Permian) there emerged the first Reptiles. From some of these ancient reptiles, long since extinct, there evolved in later ages the Birds and the Mammals.

This, then, is what is meant by the Ascent of Life, that as age succeeded age, finer and more masterful animals appeared on the scene, animals with more freedom of behaviour, with quicker wits and deeper kindliness. All through the ages, life has been slowly creeping upwards, sometimes quickly leaping, "till at the last arose the man."

What is true of animals is true of plants also. For a long time the only plants were seaweeds and moulds (Algæ and Fungi). Then came the possession of the dry land, or rather the moist land, and there was a time (of which we have little fossil record) when there was a vegetation of simple plants, something like the liverworts and mosses of to-day. Ages passed, and the vegetation of the earth was mainly fern-like—consisting of a great variety of ferns and tree-ferns, horse-tails and club-mosses. Finally, out of a fern-like stock there arose the first seed-plants, and by and by the true flowering plants, which form the greater part of the vegetation of to-day. It is a long and difficult story, but it is enough just now to recognise clearly that in the plant world, as in the animal world, there was an age-long transformation, tending on the whole towards the appearance of finer and more beautiful living creatures. But we do not know that the mind, which shines out clearly among the higher animals, ever wakened up in the plant.

"Puffing Billy" was the name given to one of Stephenson's early locomotives, so imperfect that when it met a cow it was a toss-up whether the mammal or the engine would give



Photo: Sport and General.

MANX CAT.

A variety of the ordinary domestic cat with a rudimentary tail. It is a native of the Isle of Man, and it illustrates what is meant by a discontinuous variation or mutation of the same nature as hornless cattle. When a Manx cat is crossed with a normal cat, the kittens are usually Manx-like.

way. Now what are the great differences between "Puffing Billy" and a splendid railway engine of to-day? There are two great differences. The modern locomotive is vastly more complicated, with ten parts for every one "Puffing Billy" had, and so is a bird vastly more complicated than an earthworm. In the second place, the modern locomotive is much more perfectly under control, it is more of a harmony, it is better knit together. So is a bird compared with a worm, and that is what we mean by "higher."

What we have said may serve to indicate two of the great

lines of progress among animals. On the one hand, they became more intricate, more *differentiated*, with more division of labour. On the other hand, they became more controlled, more unified, more *integrated*—partly by the nervous system, partly by the binding of one member of the body to another, partly by the common medium of the blood, and partly by the chemical messengers or hormones which help greatly in the regulation of a harmonious life.

But another main line of progress was the establishment of adaptations, by which we mean particular adjustments of structure and function that make for efficiency in reference to particular needs or circumstances. Let us take the instance of the African snake called Dasypeltis, which feeds on eggs stolen from ground-nests. It has not very good teeth, and there are not many of them, but it is able to grasp the egg in its mouth. If it broke the shell there, it would certainly lose a good deal of the precious contents. It moves forward the right side of the lower jaw, holding the egg firm on the left. Then it grips with the right side and moves the left forward. So the egg passes to the back of the mouth, is seized by the muscular swallowing part (the *pharynx* in all animals), and begins to slide down the gullet still unbroken. Now, though it is almost incredible, there are sharp enamel-pointed teeth projecting through the roof of the gullet, and when the egg-shell is pressed against these it is neatly broken, and nothing is spilled out. The cracked egg-shell is then pushed out of the mouth, for Dasypeltis always returns the " empties " ! What a series of fitnesses—the fixing teeth, the movements of the two sides of the lower jaw, the gripping part of the mouth, the elastic gullet, and the gullet teeth. And this is but a striking instance of what is true of all animals, and plants too, that they are bundles of fitnesses—special adjustments that " serve their purpose " well. But we must not pass on without thinking over these gullet teeth. How can there be teeth in a gullet ? The answer is that these are prolonged downward-pointing processes from the underside of the backbone-bodies (or vertebræ) of the neck region.

These processes are quite usual in backboned animals, but here they are long and sharp, and turned to a peculiar use in connection with a peculiar habit. *This is Nature's way.*

But another great line of progress among animals has undoubtedly been towards a greater fullness and freedom in the inner life of feeling, purpose, and understanding, which we call "mind." As we have seen, the mind of an ant or a bee is very different from that of an ape or a bird, but there are common features—of enjoyment, of looking forward, of masterful control. The big fact of the ascent of life is that this inner aspect becomes more and more important. Life conquers things and mind guides life. The story of evolution is in no small degree the story of increasing freedom of mind. What is represented by flashes in the Amœba, dreams in the coral, glimpses in the ant, becomes a more and more perfect day!

To sum up: Not only did living creatures possess every corner of the earth and sea, they became in the course of ages more complicated and more controlled, they gained fitness after fitness, and among animals there was an increased fullness and freedom of life, as the mind came to its own.

FACTORS IN EVOLUTION

Organic evolution is a process of Becoming. Our fauna and flora are descended from an antecedent fauna and flora on the whole simpler; and so on back and back until we lose our clue in the thick mist of life's beginnings. Organic evolution was compared by Samuel Butler to a fugue, in which when the subject and counter-subject have been announced, there must henceforth be nothing new, and yet all must be new; and, perhaps, we may name the subject and counter-subject of the long-drawn-out fugue of organic evolution as hunger and love. But while the evolution concept states the general way in which Animate Nature has come to be as it is—by a slow natural process of racial transformation—it does not as such disclose the factors at work in the sublime advancement (and the occasional retrogression) from age to age. That is the task of the causal

theories of evolution, which are still very young. The fact of evolution is recognised by all competent naturalists, but there is hesitation and confessed ignorance in regard to the factors. Partly through muddle-headedness and partly through intellectual dishonesty, the experts' frank admission of suspended judgment in regard to the factors in evolution has been twisted as if it implied hesitancy regarding the evolution idea in general. No competent naturalist has any such hesitancy.

Can we give any definition of Organic Evolution? This must be difficult, but we suggest the following. Organic evolution is a natural process of racial change in a definite direction (or in several definite directions in different parts) in the course of which new forms, with new adaptations and linkages, arise, take root, and flourish alongside of or in place of the originative stock. Organic evolution must be distinguished from *development*, which is the Becoming of the individual—the beech-tree or the squirrel—from their respective egg-cells onwards. It should also be distinguished from *human history*, for man stands apart in his awareness of the past, in his power to control the future, and in his capacity for registering the gains of evolution outside the organism altogether, namely, in the social heritage. It would also be of advantage to have a different word for cases like the making of the solar system. Perhaps the word *genesis* would serve. For in the separation of the earth and the other planets from the parental sun there was nothing corresponding to the processes of elimination that are characteristic of organic evolution. The original matter-and-energy—we must hyphenate them now—of the nebular mass was differentiated into a solar system, but there was no sifting. Whereas it is characteristic of organic evolution that many of the organisms that shared in the struggle did not enter into the promises. There have been many lost races.

In the domain of things the processes that come nearest those of organic evolution are to be found in radio-active changes. Thus uranium passes through a succession of changes, resulting in the production of helium gas and a

form of lead. This transmutation is in some ways like the transformation of species; but, nowadays, the *known* chemico-physical clocks are all running down, whereas the vital clocks are able to wind themselves up. Progressive evolution, as in the pedigree of horse and elephant, is much more frequent and much more characteristic than retrogressive evolution, such as is illustrated in increasing adaptations to sedentary life or to parasitism. The creative syntheses achieved by the modern chemist are not unlike those of organic evolution, and we might especially compare them to the combinations effected by the Mendelian breeder or cultivator. But the difficulty is to find synthetic processes going on nowadays in the domain of things apart from man. In the realm of organisms, on the other hand, evolution proceeds apace. New departures are common; the Proteus still leaps; life continues to flow uphill.

When we try to get a picture of the sublime process of organic evolution, which has no doubt continued for several hundreds of millions of years, we receive certain great impressions. One is the multitudinous production of individualities; there are over a quarter of a million different kinds of living animals, each itself and no other. A second impression concerns the persistence with which every possible haunt of life has been and is being peopled—from sea to land, from earth to air. A third is centred in the establishment of fitness after fitness—often with a marvellous nuance of adaptation. And then there is the largest fact that in the course of ages, as life crept upwards, the mental aspect became increasingly manifest and masterful.

The central secret of life is the origin of the new, just as the central secret of the musician or the painter is his creativeness. Among the delightful birds called ruffs there are seldom two males alike. That is what is called *variability*. Each ruff is unique—itself and no other; and so is it with every child. "The very image of his father," "a living likeness of her mother," people say; but this is not very true to life! Attention is captured by some outstanding features that are indeed continued from parent to child, but all the differences are left unnoticed. The proud

parents are right: there is no child in the world like theirs. It may not be the strongest, the cleverest, the prettiest, the best behaved—but it is unique, unless, indeed, it has an identical twin. The differences among the members of a family are often extraordinary, and that is what is meant by variability.

We have already spoken of a visit to a pigeon show, with its fantails and pouters, jacobins and barbs, turbits and owls, carriers and runts, tumblers and trumpeters, and many more besides. In the Rock-Dove (*Columba livia*), which is still common on some of our shore cliffs, we find the fountain and origin of all our domestic breeds. So with the cochins and dorkings, hamburghs and andalusians, wyandottes and houdans, silkies and bantams, all have been derived from the Jungle Fowl (*Gallus bankiva*), still thriving in Indian forests. And what shall we say of the races of canary that have arisen since the sixteenth century, or of the varieties of cabbages and apples and wheats? Even when there has been a mixture of wild species, as in the pedigree of domesticated dogs and horses, we are still left wondering at the Protean changefulness of life.

What is so striking among domesticated animals and cultivated plants—where man covers with his shield many new departures that would be speedily destroyed in Wild Nature—is also true in natural conditions: the big fact, as Sir Francis Galton said, is organic flux. There are, no doubt, some very stable conservative types, like the Pearly Nautilus, that seem to have remained the same for millions of years, but whenever we begin to peer into a large number of specimens of almost any kind of living creature we are almost certain to find a crop of novelties. Whether we take the jelly-fishes stranded on the shore or the different colours of eggs that cuckoos lay, the vertebræ of sloths or the teeth of apes, the shells of the dog-whelk or the markings of potato-beetles, the different forms of shepherd's purse or the colours of wild pansies, we are soon convinced that variation is as common among wild creatures as in conditions of domestication and cultivation. But, as we have said, Nature is not so tolerant as man, and, in

natural conditions, many tentatives are only born to die. It is plain, for instance, that Nature could never tolerate a pigeon with a bill so short that it could not break its way out of the eggshell. Many of man's pets in the dog line would make a rapid exit in Wild Nature.

It must not be supposed that all the differences that we observe between living creatures of the same kind have equal evolutionary value, for some of them are merely dints or imprints that are directly due to peculiarities in surroundings, food, and habits, while others are outcomes or expressions that are due to changes in the secret recesses of the germ-cells. As we are not certain that changes of the first kind can be handed on, it is to those of the second kind that we must look as furnishing the raw materials of evolution. To put it more technically, when we subtract from the total of "observed differences" all that can be reasonably regarded as "modifications," we are left with "variations," and these are the new departures that count.

It is very interesting to inspect the collection of a Lepidopterologist who "goes in for varieties." We ask to be shown the "currant moth," for instance, and the collector smiles a little, for he pulls out three drawers with scores and scores of different patterns. So it is in many other cases; it is the story of the ruffs over again, though we suspect that many of the collector's "varieties" are only transient "modifications" of no more evolutionary interest than ill-fed children with pale faces.

It has been calculated that if we could arrange a great cinema film of the evolution of living creatures, giving proportionate lengths to the successive geological periods and organic dynasties, arranging the whole so that it could be unrolled at uniform rate throughout a day, beginning at 9 a.m., then man would appear on the film just a few minutes before midnight! Yet man only among all living creatures is aware of the long drama, and even he has but a dim understanding of the plot.

But while naturalists are far from being clear as yet in regard to the factors in Organic Evolution, and while philosophers cannot clearly explain to us the glimpses they

get of the Purpose of it all, there is no doubt as to the fact that there has been throughout the ages a long succession of achievements. Defeats, retrogressions, degenerations, parasitisms, blind alleys, there have been ; yet on the whole Organic Evolution has been progressive. As age succeeded age, there has been an emergence of nobler and finer forms of life—an increase of feeling, perception, and control—in short, a growing emancipation of "Mind." This has its highest expression in Man at his best—with a personality growing in understanding, goodwill, and control. And this evolution is going on.